7th International Conference on Strength Training

October 28 – 30, 2010 • Bratislava • Slovakia

ABSTRACTS

Editor:
Dušan Hamar

Organized by

Conference organizers
Slovak Society of Sports Medicine
Faculty of Physical Education and Sport Comenius University
Slovak Olympic Committee

International Scientific Committee

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Members:
William J. Kraemer, USA
Dietmar Schmidtbleicher, Germany
Steven Fleck, USA
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ISBN 978-80-89460-02-1

Welcome

On behalf of all three organizers Faculty of Physical Education and Sport Comenius University, Slovak Society of Sports Medicine, and Slovak Olympic Committee we have the pleasure to welcome you to the 7th International Conference on Strength Training.

Traditionally this multidisciplinary meeting brings together scientists, coaches, medical doctors and other health professionals from all over the world to share the most up to date research related to strength training.

Format of the conference is based on key note lectures presented by invited recognized scientists complemented by reviewed submitted contribution in form of oral podium presentations, defended and non-defended posters.

Also this edition of the conference series brings not only deeper insight into mechanisms of muscle response to mechanical loading, but also practice relevant information related to enhancement of the effects of strength training for both performance and health.

We sincerely hope you will enjoy the 7th International Conference on Strength Training.

Prof. Dušan Hamar, MD, PhD
Conference Chairman

Contents

Registration

Registration stand in the main entrance lobby of the Faculty of Physical Education and Sports Comenius University (Svobodovo nabr. 9, 814 69 BRATISLAVA) will be open between 14:00 and 20:00 on October 27^{th}, 2010, 7:00 and 19:00 on October 28^{th} as well as during conference hours on October 29^{th} and 30^{th}, 2010.

In addition to registration services staff will be available to answer any questions and assist the participants.

General Information

1. Instructions for Oral Presentation

Total time of 40 minutes (including 5 minutes for discussion) is allocated for key note speakers. For podium presentations only 8 minutes are available for presentation followed by 2 minutes of discussion led by the moderator. Speakers have to ensure that they stay on time as the sessions are closely scheduled. The speakers must load their presentations on USB flash drive or CD to the PC on the speakers' counter of the conference auditorium at least in the last break before the start of their session.

Assistance from the staff technician will be provided.

2. Instructions for Defended Poster Presentations

Defended poster session I will take place on October 28th, 2010 from 16:30 till 18:15 in the rooms 070 and 071 (on the right corridor as going out of the main auditorium area).

Defended poster session II will take place on October 29th, 2010 from 12:30 till 13:00 in the room 071.

All posters shall be placed on their respective boards at least 30 minutes prior to the start of the session.

Speakers will have maximum 3 minutes for short oral presentation followed by discussion led by the moderator.

3. Instructions for Non-Defended Poster Presentations

Poster should be placed on the designated boards at the latest by 14:00 on October 28th, 2010 and may remain displayed till October 30th, 16:30.

Social Events

1. Welcome Reception

October 28th, 19:00, Dining Hall of Faculty of Physical Education and Sport Comenius University.

2. Trip to the Castle Červený kameň (Red Stone) with wine tasting in Little Carpathian region.

A very popular sightseeing tour driving trough the historic viticulture towns of the Small Carpathians wine region, also known as the Small Carpathians Wine Route. The highlight is a visit to Červený kameň (Red Stone) Castle, one of Slovakia's most beautiful with largest wine cellars in central Europe, for a guided tour.

Afterwards you will participate in a wine tasting in one of region's wine cellars where you will sample delicious local wines. Your guide will be a person devoted to history and wine.

The trip is free for registered participants, however, signing up will be required at the registration.

3. Closing Banquet

October 30th, 20:00 (venue TBD).

Banquet is free for registered participants, however, signing up will be required at the registration.

Program at a glance

Thursday, October 28th, 2010

8:15-8:30	**Opening Ceremony**
8:30-10:30	**Physiology and Endocrinology of Resistance Training**
10:30 -11:00	*Coffee break*
11:00-13:00	**Strength Training and Aging**
13:00-14:00	*Lunch*
14:00-16:00	**Oral Podium Presentations I.**
16:00-16:30	*Coffee break*
16:30-18:15	**Defended Poster Session I (room 0-70 and 0-71)**
18:15-19:15	**Non-defended Poster Session**
19:30	**Welcome reception**

Friday, October 29th, 2010

8:30-10:30	**Enhancement of Strength Training with Nutrition and Technology**
10:30-11:00	*Coffee break*
11:00-12:20	**Strength Training in Clinical Practice**
12:20-12:30	*Break*
12:30 – 13:00	**Defended Poster Session II (room 0-70 and 0-71)**
13:00-14:00	*Lunch*
14:00-19:00	**Social Program**

Saturday, October 30th, 2010

8:30-10:30	**Mechanisms of Muscle Adaptation to Resistance Training I.**
10:30-11:00	*Coffee break*
11:00-12:45	**Oral Podium Presentations II.**
12:45-13:45	*Lunch*
13:45-15:05	**Mechanisms of Muscle Adaptation to Resistance Training II.**
15:05-15:30	*Coffee break*
15:30-17:30	**A Sport Specific Approach to Strength Training**
17:30-18:00	**Announcement of International Scientific Committee of Conference Series on Strength Training**
	Questions and Answers
	Closing Ceremony
20:00	**Closing Banquet**

Keynote Bios

Claudio Gil Araújo
Prof. Araújo received his MD by Federal University of Rio de Janeiro - Brazil in 1979. He received his PhD (Physiology) by Federal University of Rio de Janeiro - Brazil in 1987. He was a post-doctoral fellow and Visiting Scientist in 1993 at Department of Pediatrics - McMaster University (Canada). He is a Professor of Physical Education Graduate Program - Gama Filho University in Rio de Janeiro, Brazil. He is also a Medical-Director - CLINIMEX - Exercise Medicine Clinic in Rio de Janeiro, Brazil.
H-index = 9, 355 citations and 50 Medline listed papers.
ResearcherID: http://www.researcherid.com/rid/A-7027-2008

Norbert Bachl
Exercise Physiologist, born in Vienna, Austria, 1947. Medical Doctor, Professor of Exercise and Sports Physiology, Head of the Department of Sports and Exercise Physiology, Head of the Institute of Sports Science University of Vienna. Previously Dean of the Faculty of Human and Social Sciences, University of Vienna. Director of the Austrian Institute of Sports Medicine. He has contributed to several topics related to sports exercise physiology, prevention and rehabilitation, especially methodological aspects of stress testing, anaerobic testings, strength testing in different environments; also engaged in space physiology concerning strength measurement and strength training in microgravity. Honorary President of the Austrian Association of Sports Medicine. Vice President of the Austrian Federation of Space Medicine and Life Science (since its foundation); Member of the Executive Committee of the International Federation of Sports Medicine (FIMS) since 1994, FIMS Vice President since 2006. Former President of the European Federation of Sports Medicine Associations (EFSMA), Member of the Medical Commission of the European Olympic Committee (EOC) from 2002 and of the International Olympic Committee since 2004.

Steve Fleck
Steven J. Fleck, Ph.D. is presently the Chair, Sport Science Department, The Colorado College, Colorado Springs, Colorado and formerly the Program Director of the Physical Conditioning Program for the U.S. Olympic Committee. Dr. Fleck's research interests include physiological adaptations to resistance training and the application of research findings to optimize resistance training program design. His research interests are not limited to physiological adaptations and the training of athletes, but also includes the general population and various disease states. In particular Dr. Fleck has research interests in the effect of physical training in breast cancer and childhood leukemia patients. During his career Dr. Fleck has designed programs for celebrities interested in general health and fitness, as well as Olympic athletes in a wide variety of sports. He has authored numerous peer reviewed research articles as well as numerous lay articles in the area of resistance training. Dr. Fleck has also authored several books concerning resistance training including *Designing Resistance Training Programs, Strength Training for Young Athletes,* and *Optimizing Strength Training: Designing Nonlinear Periodization Workouts*. All of these books have been translated into several languages. He is a Fellow of both the American College of Sports Medicine and the National

Strength and Conditioning Association. For his work he has been honored by receiving both the National Strength and Conditioning Association's Sports Scientist of the Year Award and the Lifetime Achievement Award of that organization.

Geoffrey Goldspink
Geoff Goldspink, PhD, Royal Free and University College Medical School - Professor Goldspink's first degree was in chemistry with courses in biological sciences and then he did a PhD at Trinity College University of Dublin. Ten years after receiving his PhD he was awarded a higher doctorate (ScD) by Trinity College for contributions to the biomedical sciences. After his PhD he took a faculty position in England to establish a Research Unit to study muscle growth and he spent a sabatical year at the University of Pennsylvania as a Fulbright Scholar and as an Assistant Professor of Biochemistry in 1970. After he returned to England, he became a Professor and later Chairman of the Department. During the time he spent further periods at Universities in the United States including the University of Wisconsin at Madison, Duke University and as a Distinguished Professor at UCLA and a Visiting Agassiz Professor at Harvard University. He then joined the Faculty of the Medical Schools of Tufts University Boston with the objective of strengthening the basic sciences in the Veterinary School and establishing a Musculo-skeletal Research Unit on the Veterinary Campus at Grafton, Massachusetts. After 4 years at Tufts he returned to the UK to up take the Foundation Chair of Veterinary Molecular and Cellular Biology at the Royal Veterinary College, University of London. After 5 years he moved to the Medical Faculty and became Head of Anatomy at the Royal Free Campus and Chairman of the Division of Basic Medical Science. His research work in Boston and in London focussed on the molecular regulation of muscle growth and maintenance which is still his major interest. Following the cloning of mechano growth factor which is expressed by normal muscle following resistance exercise he resigned his administrative positions to concentrate on his research. Also as well as research grants his work is now funded by a major pharmaceutical company who are preparing for clinical trials for the treatment of muscle wasting conditions including muscular dystrophy, ALS, muscle cachexia and sarcopenia.

Marcus Gruber
Born in 1970 in Ehenbichl Austria, Markus Gruber studied Physical Education in Sport Science and Chemistry at the University of Stuttgart, Germany where he later on did his Doctorate in Sport Science. After his Doctorate he worked, first, as an Assistant and later, as a Senior Lecturer, at the Department of Sport Science, University Freiburg, Germany where he did his Habilitation thesis, entitled “Sensorimotor Training and Neural Plasticity”. In 2007 Markus Gruber spent one year as a Senior Researcher at the Neuromuscular Research Center, Department of Biology of Physical Activity, University of Jyväskylä , Finland. From 2008 to 2010 he worked as a Full Professor for Training- and Movement Science at the University of Potsdam, Germany. Since October 2010 he is Full Professor for Sport Science at the University of Konstanz, Germany. His research focus is on the Biology and Physiology of human performance and movement and on the mechanisms and adaptations of functions in human exercise.

Arja Häkkinen
Arja Häkkinen is a professor at the Department of Health Sciences, University of Jyväskylä and Department of Physical Medicine in Jyväskylä Central Hospital.
Her study background includes programming of training and testing of physical function and co-impairments in the disablement process especially in musculoskeletal diseases.

Keijo Häkkinen
Keijo Häkkinen is a professor and head of the Department of Biology of Physical Activity, and a vice-dean of the Faculty of Sport and Health Sciences at the University of Jyväskylä, Jyväskylä, Finland. He has contributed to nearly 300 peer-reviewed international scientific publications, about 50 review articles, chapters in books and books and over 150 domestic publications. His research interests are wide but the major focus is within neuromuscular performance, resistance exercise induced fatigue & recovery, aging & neuromuscular system, with special interests in neuromuscular and hormonal adaptations during strength training and combined strength and endurance training. Dr. Häkkinen has co-operated in research with several domestic and international universities, reviewed a large number of scientific manuscripts and acted on the editorial boards of several scientific journals. He has given around 100 presentations in international scientific congresses and seminars. He has been a member of selected international scientific societies and a chair of scientific and organizing committees of several international congresses.

Dušan Hamar
Dušan Hamar received his MD from Medical Faculty of Comenius University in Bratislava. He is a specialist in Internal Medicine and Sport Medicine. He received his PhD in Sports Medicine from the same Faculty in 1985. Currently he is a professor of Sport Kinanthropology at the Faculty of Physical Education and Sport in Bratislava, Slovakia. He served two decades as a board member as well as a chairman of Scientific Commission of FIMS (International Federation of Sports Medicine). His scientific interests in strength conditioning come from his sports carrier as international level shot putter. He has developed several strength testing and training enhancement systems used by strength and conditioning proffessionals in both gyms as well as in exercise testing labs.

Hiroshi Hasegawa
Hiroshi Hasegawa is a Professor of Sports Science Laboratory at the Ryukoku University in Kyoto, Japan. Between1997-1998 he was a Visiting Scholar of the Laboratory for Sports Medicine at the Pennsylvania State University. Between 1998-2002 he was the Vice President of the National Strength & Conditioning Association Japan. Since 2006 he is a Board Member of the Japan Association of Training Instructors. Between 2005-2008 he was a Conditioning Adviser in Nagoya Grampus Football Club (Professional J-1 Football League). Since 2008- Director of Sports Science in Honda Rugby Football Club. Co-Author of "Strength Training for Athletes" The International Olympic Committee (IOC) Medical Commission, Blackwell, 2002.

John Ivy
Dr. John Ivy is the Chair of Kinesiology at the University of Texas, and holder of the Teresa Lozano Long Endowed Chair. He received his Ph.D. in Exercise Physiology from the University of Maryland and post-doctoral training in physiology at Washington University School of Medicine. Dr. Ivy's research has pioneered our understanding of how muscles work and how nutritional supplementation can improve muscle performance and recovery from exercise. He is the author of over 150 scientific papers, numerous book chapters and two books on sports nutrition – "Nutrient Timing" and "The Performance Zone".

Helmut Kern
Professor Helmut Kern has been the Head of the Research Institute „Ludwig Boltzmann Institute of Electrical Stimulation and Rehabilitation" in Vienna, Austria since 1999. He has also been the Head of the „Department of Physical Medicine and Rehabilitation" Wilhelminenspital, Vienna, Austria since 1984. Between years 1988 and 2009 he was a Medical director of "Academy of Physiotherapy" Wilhelminenspital, in Vienna, Austria. From 1988 till 1999 he was the Founder of the "Ludwig Boltzmann Research Center for Electrical Stimulation and Rehabilitation.

Michael Kjær
Professor of Sports Medicine at University of Copenhagen, and Chief Physician (Rheumatology) at Institute of Sports Medicine, Copenhagen University Hospital at Bispebjerg. Main interest in muscle and matrix biology in relation to exercise and sports. To understand adaptation and regeneration in sports injury on tendon and muscle.

William J. Kraemer
Dr. William J. Kraemer is a full professor in the Department of Kinesiology in the Neag School of Education working in the Human Performance Laboratory at the University of Connecticut, Storrs, CT. He also holds an appointment as a full professor in the Department of Physiology and Neurobiology along with an appointment as a full Professor of Medicine at the UCONN Health Center/School of Medicine. Dr. Kraemer has received numerous honors for his many accomplishments during his career. Dr. Kraemer was honored by the University of Connecticut with its highest research award, the Provost Research Excellence Medal in 2005 and the University of Connecticut's Alumni Research Excellence Award for Sciences in 2009. Dr. Kraemer is currently a Fellow in the American College of Sports Medicine and the National Strength and Conditioning Association (NSCA). The NSCA gave him their Lifetime Achievement Award and also named their sport science award in his honor, the "William J. Kraemer Outstanding Sport Scientist Award" in 2005. In 2004 he was inducted into the USA Strength Coaches Hall of Fame in the contributor division for his contributions to the field. He has authored and co-authored over 350 manuscripts in the peer reviewed scientific literature related to sports medicine, exercise endocrinology, sports nutrition and supplementation efficacy, and exercise and sport science. In addition, he has authored or co-authored 10 books in the areas of strength training and physiology of exercise.

Heikki Kyröläinen
I was found competent for professorships in Exercise Physiology in 2003, Biology of Physical Activity in 2005, Kinesiology in 2006, and Biomechanics in 2007. Now I'm acting as a professor in biology of physical activity, specialized especially for soldier's physical performance. I'm also the Head of Pedagogical Affairs in the Department of Biology of Physiology. I have published about 90 original articles in the scientific international journals (ref.). In addition, about 140 proceedings or abstracts and some books and chapters in the books have been published.

Zsolt Radák
Zsolt Radák received a doctor degree from the Hungarian University of Physical Education in 1990 and a PhD from the University Tsukuba in Japan in 1996. He has worked as a national coach of the Hungarian Track and Field National Team. He has received Hungary's Bolyai Research Fellowship in Medicine and then Szechenyi professorship from the Hungarian Academy of Science. He is the DSc of Hungarian Academy of Science at the field of medicine. He is a professor and serves as an associate-dean of the Faculty of Physical Education and Sport Science of Semmelweis University, Budapest, Hungary. From the year of 2008 he is the head of the only Sport Science Doctoral School in the University. His articles have been published in the Journal of Applied Physiology, Archives of Biochemistry and Biophysics, Neurochemistry International, Experimental Gerontology, Aging Research Reviews, Journal of Alzhemier Diseases, Free Radical Biological Medicine and FASEB Journal.

Dietmar Schmidtbleicher
Prof. Dr. Dr. h. c. Dietmar Schmidtbleicher, Head and Chair for Sport Sciences at the Institute of Sport Sciences at the Johann Wolfgang Goethe-University Frankfurt/Main in Germany. Main topics in his work are strength and power training, neuronal and muscular adaptations after training, diagnostics and regulation of training and the development of measurement devices. Furthermore he developed a method for training in high performance sports and rehabilitation using stochastic resonance.
He published more than 400 articles and is a leading expert for strength and power training especially for top level athletes.

József Tihanyi
Born in 31/10/1946. Graduated in the Hungarian University of Physical Education 1970. He is full professor of Biomechanics at the Faculty of Physical Education and Sport Sciences, Semmelweis University, Budapest. He was rector of the Hungarian University of Physical Education (1994-2001) and he is the dean for the Faculty of Physical Education and Sport Sciences. He has been visiting professor in Zagreb University, Tor Vergata University (Rome), Claude Bernard University (Lyon), Kuwait University teaching biomechanics and training theory and methodology. He published 131 scientific and professional papers in several languages. He was invited lecturer more than fifty times in international conferences. He is entitled with doctor of Science in the Hungarian Academy of Science. He has been member of the editorial board and reviewer of several international scientific journals. He was Hungarian champion and record holder in high jump and the coach for international calibre high jumpers.

Truls Raastad

Truls Raastad is a Professor in Exercise Physiology. He is at the Department of Physical Performance, Norwegian School of Sport Sciences. His PhD thesis in 2001: Neuromuscular fatigue, recovery and hormonal responses to strength exercise and heavy training. His main research topics include: Muscle physiology, recovery of muscle function, muscle damage, strength training and performance. He is also a Consultant for the Sport Nutrition Department in the Norwegian Olympic committee.

Harald Tschan

Harald Tschan born 1961 is Ass. Professor at the Faculty of Sport Science at Vienna University where he works at the Department of Sports and Exercise Physiology. He holds a Master of Science and a PhD in Sport Science from the University of Vienna and a degree from the International Space University ISU. In addition to teaching in Austria, Italy and USA, Dr. Tschan is actively involved in research with a focus on the musculoskeletal system. His primary research interest includes changes in physiological parameters associated with acute and chronic training and inactivity. Prior to his position in the Department of Sport and Exercise Physiology at Vienna University Dr. Tschan was collaborator in several national and international scientific projects. Working in Austrian – Russian Space Projects he was responsible for experimental design, pre and post-flight data collection, documentation and data analyzes from MIR long-term space missions, and at the Exercise Physiology Laboratory of NASA in JSC Houston/Texas he was involved in testing the exercise equipment for the International Space Station ISS. Currently he is again involved in two space projects with the European Space Agency where he is member of the Scientific Board and with the Russian Space agency where he is involved in the isolation study “Mars 500” – a study simulating the flight to Mars. Dr. Tschan is also heavily involved in the curriculum development and in harmonizing the curriculum of Sport Science in the Balkans and in Egypt within European Union Tempus projects. In his young years Dr. Tschan was competitive athlete in athletics on a international level and he is now Board Member of the Austrian Athletic Association and Vice President of Austrian’s biggest athletic club. Dr. Tschan has authored or co-authored about 100 publications, and was invited peer reviewer for several scientific journals. At the FIMS World Congress of Sports Medicine in Beijing 2006 Dr. Tschan received the FIMS Best Paper Award in Sports Science. In 2010 he received the Mohammmed Bin Rashid Al Maktoum Creative Sports Award.

Barbara Wessner

Barbara Wessner is a molecular biologist with a strong background in nutritional science and immunology. Previously, Research Associate and lecturer at the Medical University of Vienna (1999-2006), now entrusted with the task to establish and manage a molecular biology laboratory at the Department of Sports and Exercise Physiology located at the Institute of Sports Sciences at the University of Vienna which aims to study molecular, cellular, physiological and integrative processes of normal and altered skeletal muscle during health, ageing and disease.

PROGRAM

Thursday, October 28th, 2010

8:15-8:30 Opening Ceremony

8:30-10:30 Physiology and Endocrinology of Resistance Training
Moderator: Keijo Häkkinen (Finland)

Kraemer, W. J. (Storrs, USA)
Physiology of Resistance Training: Implications for Program Design

Gruber, M. (Potsdam, Germany)
Neural Control of Force Development during the Stretch Shortening Cycle

Kyröläinen, H., Häkkinen, K., Santtila, M., Nindl, B.C. (Jyväskylä, Finland)
Acute and Chronic Neuromuscular and Hormonal Responses to Strength and Endurance Military Exercises

10:30 -11:00 Coffee break

11:00-13:00 Strength Training and Aging
Moderator: William J. Kraemer (USA)

Häkkinen, K. (Jyväskylä, Finland)
The Aging Neuromuscular System in Men and Women Still Responds to Systematic Strength Training

Kjaer, M. (Copenhagen, Denmark)
Skeletal Muscle Stem Cells and Muscle Regeneration: Effect of Ageing

Araujo, C. (Rio de Janeiro, Brazil)
Long-term Adaptations in Middle-aged and Old Subjects Attending a Supervised Exercise Program

13:00-14:00 Lunch

14:00-16:00 Oral Podium Presentations I.
Moderator: Dušan Hamar (Slovakia)

Harris, N., Godfrey, A., Cronin, J., Jidovtseff, B. (New Zealand)
Rubber Based Resistance and the Bench Press Exercise: Force and Power Outputs

Van den Tillaar, R., Tveit, M., Sæterbakken, A., Marques, M. (Norway)
Is the Existence of the Sticking Region in Bench Press the Result of Diminishing Potentation or a Mechanical Poor Force Region?

Kneževic, O., Pažin, N., Planić, N., Mirkov, D. (Serbia)
Effect of Different Joint Angles on the Knee Flexor and Extensor Rate of Force Development during Maximal Isometric Contraction

Peltonen, H., Häkkinen, K., Avela, J. (Finland)
Neuromuscular Responses to Different Loading Protocols Using Pneumatic and Weight Stack Devices

Ekblom, M., Eriksson, M. (Sweden)
Action Type Specific Effects from Concurrent EMG Feedback from Vastus Medialis in Females

Jidovtseff, B., Bruls, O., Tubez, F., Monfort, L., Harris, N., Cronin, J.B., (Belgium)
Using Interia Measurement Unit (IMU) For Exercise Analysis

Holviala, J., Kraemer, W.J., Sillanpää, E., Avela, J., Häkkinen, A., Häkkinen, K. (Finland)
Effects of Combined Strength and Endurance Training on Dynamic Strength, Walking, Performance and Balance in Aging Men

Piirainen, J., Avela, J., Linnamo, V. (Finland)
Dynamic Balance Control After Pneumatic and Plyometric Training

Chung, P., Ling, G., Liu, Ch., Chuang, L., Shiang, T. (China)
Balance Effects of Tai Chi Chuan Combined with Vibration Training

Hajduk, K., Schlumberger, A. (Germany)
Effects of Core Stability Exercises on Maximum Force and Postural Control of the Lower Extremity during 1RM Squat Performance

Lehnert, M., Lamrová, I. (Czech Republic)
Changes in Speed and Strength in Female Junior Volleyball Players After a Plyometric Training Program

Marín, P.J., Santos-Lozano, A., Santin-Medeiros, F., Delecluse, C.H., Garatachea, N. (Spain)
Effects of Whole-Body Vibration vs. Conventional Squat Exercise on Electromyographic Responses and Rate of Perceived Exertion

16:00-16:30 Coffee break

16:30-18:15 Defended Poster Session I (room 0-70 and 0-71)
Moderators: Claudio G. Araujo (Brazil)
John Ivy (USA)
Heikki Kyröläinen (Finland)

1. Carvalho, C., Vieira, L., Martins, C., Carvalho, A. (Portugal)
Strength Training Associated to Specific Plyometrics: The Development of Vertical Impulse Strength in Female Volleyball Players

2. Kraemer, W.J., Wolf, M.R., Fragala, M.S., Denegar, C.R., Volek, J.S., Anderson, J.M., Comstock, B., Dunn-Lewis, C., Häkkinen, K., Maresh, C.M. (USA)
Effects of Estrogen on Muscle Damage in Response to an Acute Resistance Exercise Protocol

3. Tarnanen, S., Neva, M., Kautiainen, H., Pekkanen, L., Ylinen, J., Kaistila, T., Häkkinen, A. (Finland)
Trunk Muscle Strength Three Months after Lumbar Spine Fusion

4. Cleather, D.J., Goodwin, J.E., Bull, A.M.J. (United Kingdom)
Knee Ligament Loading Vertical Jumping and Push Jerking

5. Signorell, G.R., Brito, L., Batista, H.M., Duarte, C.V., Cascon, R.M., Perim, R.R., Araujo, C.G. (Brazil)
Does Long-term Strength/Power Training Counteract Age Related Muscle Power Decline?

6. Ignjatovic, A,. Stankovic, R., Radovanovic, D., Markovic, Z., Stojiljkovic, N. (Serbia)
Effects of Resistance Training on Muscle Strength and Power in Trained Young Basketball Players

7. Radovanovic, D., Bratic, M., Nurkic, M., Stankovic, N. (Serbia)
Twelve Weeks of Strength and Endurance Training Effects on Anaerobic Capacity and Cardiorespiratory Endurance in Judokas

8. Cvečka, J., Hamar, D. (Slovakia)
Effect of Serial Stretch Loading on Selected Parameters of Strength Capabilities

9. Marín, P.J., Torres-Luque, G., Hernández-García, R., García-López, D., Garatachea, N.(Spain)
Comparing the Effects of Different Vibration Exercises Between-sets on Upper Body Performance in Elite Judo Athletes

10. Malý, T., Zahálka, F., Malá, L. (Czech Republic)
Bilateral Isokinetic Strength Profile of Knee Flexors and Extensors in Soccer Players

11. Ponorac, N., Ignjatovic, A., Radovanovic, D., Stankovic, R., Stojiljkovic, N. (Bosnia and Herzegovina)
Influence of Resistance Training on Cardiorespiratory Endurance in Young Athletes

12. Jandačka, D., Jandačka, P., Vaverka, F. (Czech Republic)
The Optimal Load for the Thrower's Dynamic Effort Strength Training Determined by Usage of Different Methods

13. Kvorning, T., Haubro, M., Bech, S., Hansen, L. (Denmark)
Optimizing Rowing Specific Power in 4 Elite Female Rowers by Heavy Strength Training

14. Panjan, A., Šarabon, N., Šimunič, B. (Slovenia)
Differences in Maximal Voluntary Contraction Values are Not Mirrored in the Ability for Submaximal Force Gradation

15. Strejcová, B., Baláš, J. (Czech Republic)
The Reliability of Shoulder Strength Testing in Regard to Gender

16. Kneževic, O., Pažin, N., Kadija, M., Milovanović, D., Mirkov, D. (Serbia)
Prediction of Optimal Isometric Hamstring to Quadriceps Ratio

17. Piitulainen, K., Häkkinen, A., Salo, P., Ylinen, J. (Finland)
Strength and Function of the Shoulder Two Months after the Rotator Cuff Reconstruction

18. García-Pallarés, J., Sánchez-Medina, L. (Spain)
Full Squat Load-Power Profile: Gender Differences

19. Matúš, I., Macejková, Y., Putala, M. (Slovakia)
Analysis of Horizontal and Vertical Forces in Different Starts Positions in Competitive Swimming

20. Putala, M., Macejková, Y., Matúš, I. (Slovakia)
Evaluation of Monitoring the Force Parameters in Breaststroke

21. Keränen, J., Piirainen, J.M., Linnamo, V. (Finland)
Effects of Different Warm-Up Protocols on Neuromuscular Functions

18:15-19:15 Non-defended Poster Session

22. Igawa, T., Kanzaki, H., Uchida, R., Shimokochi, Y. (Japan)
Maximum Core Stability is related to Coaches´ Subjective Evaluations of Kendo Performance

23. Tricoli, V., Laurentino, G., Aoki, MS., Roschel, H., Soares, A.G., Neves, Jr. M., Aihara, A.Y., Fernandes, A.R.C., Ugrinowitsch, C. (Brazil)
Effects of Strength Training with Partial Vascular Occlusion on Skeletal Muscle Hypertrophy and Myostatin Gene Expression

24. Oishi, A., Nagata, A., Shimokochi, Y. (Japan)
Relationship between Maximum Core Stability and Isokinetic Trunk Flexion Strength

25. Ivanovic, J., Dopsaj, M. (Serbia)
Factor Structure of Indicators for Evaluating Leg Extensors Explosive Force in Female

26. Cholewa, J., Mikolajec, K., Zajac, T., Gerasimuk, D., Jazic, D. (Poland)
Acute Effects of Intensive Stretching on Running Speed and Power in Basketball Players

27. Dopsaj, M., Vučković, G., Ivanović, J. (Serbia)
Changes in Maximal force of Basic Muscle Groups in Handball Female Players Regarding Different Age Groups Category Transversal Model

28. Nurkic, M., Bratic, M., Stankovic, N., Radovanovic, D. (Serbia)
The Effects of Resistance Training on Muscular Strength and Endurance in Young Judokas

29. Netreba, A., Bravyy, Y., Zakirova, A., Vinogradova, O. (Russia)
Strength Training Protocol for Improving Motor Control Effectiveness during Maximal Effort

30. Vanderka M, Hamar D, Kampmiller T, Mihalík T, Novosád A (Slovakia)
Adaptation Effects of Explosive Weight Training with vs. without Counter-Movement

31. Terzis, K., Karampatsos, G., Kyriazis, T., Zaras, N., Akrivakis, P., Georgiadis, G. (Greece)
Acute Increase in Shot Put Performance after Sprinting

32. Taipale, R., Mikkola, J., Salo, T., Hokka, L., Vesterinen, V., Nummela, A., Häkkinen, K. (Finland)
Neuromuscular, Cardiovascular, and Hormonal Adaptations to Prolonged Concurrent Strength and Endurance Training in Male and Female Recreational Runners

33. Laczo, E., Sedliak, M., Cvečka, J., Buzgó, G., Zelko, A. (Slovakia)
Time Specific Strength Training Induced Hypertrophy and Muscle Strength Increase of Young Untrained Men

34. Zajac, A., Waśkiewicz, Z., Czuba, M., Czernecki, R., Cholewa, J. (Poland)
The Effects of a High Fat Diet on Anaerobic Power, Body Mass, Body Composition and Anabolic Hormone Profile in Strength Trained Athletes

35. Buzgó, G., Šelingerová, M., Šelinger, P. (Slovakia)
Bone Mineral Density of Young Weightlifters with Relation to Their Natural Development

36. Lovell, Ch., Blagrove, R. (United Kingdom)
Three Different Intensities of Back Squat Failed to Potentiate Squat Jump

37. Marín, P.J., Herrero, A.J., García-López, D., Rhea, M.R., López-Chicharro, J., González-Gallego, J., Garatachea, N. (Spain)
Effects of Vibration Exercise on Electromyography Activity and Rating of Perceived Exertion in Older Individuals

38. Liu, Ch., Wang, H., Chien, Y., Chuang, L., Shiang, T. (Taiwan)
Effects of Vibration Training Modes with Different Frequencies and Amplitudes on Knee Extensor Strength

39. Tse, M., McManus, A., Masters, R. (China)
The Influence of Core Stability on Kinematics and Performance in Rowing

40. Vokoun, O. (Czech Republic)
Strength and Power Training at Junior National Team in Alpine Skiing

41. Legg, H.S., Goodwin, J.E., Glaister, M. (United Kingdom)
The Effect of Foot Inclination on the Back Squat

42. Kováčiková, Z., Zemková, E., Hamar, D. (Slovakia)
Power in Concentric Phase of Chest Presses while Lifting Different Weights under Stable and Unstable Conditions

43. Yadolazade, A., Namazizadeh, M., Musavi, S.M.K.V., Jourkesh M. (Iran)
The Effect of Mental and Physical Practice on Muscle Electrical Activity in Force Production Task

44. Price, P., Goodwin, J.E., Legg, H.S., Twell, S., Boycott-Brown, D.M., Cleather, D.J. (United Kingdom)
Tibiofemoral and Patellofemoral Joint Forces during Squatting at Varying Loads and Depths

45. Goodwin, J., Cleather, D.J., Bull, A.M.J. (United Kingdom)
Muscle Function and Joint Moment Contributions to Between Jumping and Jerking

46. Manno, R., Mirri, G.G., Morandini, C., Faina, M. (Italy)
Gender Differences in Explosive Strength in Top Level Athlete

47. Sugiyama, K., Okajima, T., Kanbayashi, I., Okayasu, T., Sasaki, T., Suda, Y., Yokota, M., Oikawa, K., Gyotoku, Y., Yamauchi, T. (Japan)
The Influence of Lifestyle on Physical Fitness of Elementary and Junior High School Children in Hokkaido

48. Zemková, E., Hamar, D. (Slovakia)
Unstable Support Base Compromises Power Output in Concentric Phase of Resistance Exercise

49. Judge, L., Bellar, D., Bodey, K., Prichard, M., Wanless, E. (USA)
An Examination of Pre-Activity and Post-Activity Stretching Practices of NCAA Division I and NCAA Division III Basketball Programs

50. Judge, L., Lee, D., Bellar, D., Gilreath, E., Wanless, E. (USA)
Resistance Training Patterns Among University Students

51. Zeissler, S. (Germany)
Effects of 6 Months Strength Training on Type2 Diabetes Patients

52. Csapo, R., Durán, L.A., Baron, R. (Spain)
Intrinsic Muscle Strength is Inversely Related to Physiological Cross-Sectional Area

53. Bauer, J., Zemková, E. (Germany)
The Effects of 12 Weeks of Resistance Training Under Stable and Unstable Conditions on Neuromuscular Performance in Handball Players

19:30 **Welcome reception**

Friday, October 29th, 2010

8:30-10:30 Enhancement of Strength Training with Nutrition and Technology
Moderator: Paavo Komi (Finland)

Ivy, J. (Austin, USA)
The Effect of Carbohydrate/Protein Supplementation on Training Adaptation

Tschan, H., Bachl, N. (Vienna, Austria)
Resistance Exercise Training to Counteract Muscle Atrophy and Strength Loss in Long Term Spaceflight

Hasegawa, H. (Kyoto, Japan)
A Real Time Feedback and Monitoring of Speed and Power in Resistance Training for Athletes.

10:30-11:00 Coffee break

11:00-12:20 Strength Training in Clinical Practice
Moderator: Dietmar Schmidtbleicher (Germany)

Häkkinen, A. (Jyväskylä, Finland)
Benefits of Strength Training in Musculoskeletal Diseases

Kern, H. (Vienna, Austria)
Electrical Induced Force Training in Humans with Complete Lower Motor Neuron Lesion

12:20-12:30 Break

12:30 – 13:00 Defended Poster Session II (room 0-70 and 0-71)
Moderator: Markus Gruber (Germany)

54. Jidovtseff, B., Harris, N., Cronin, J.B., Quievre, J. (Belgium)
Relevance of Acceleration and Gravity Power Profiling for Training Prescription

55. Patterson, C., Barth, A., Barth, M., Raschner, Ch. (Austria)
A New Augmented Eccentric Loading Device: Free Barbell Repetitions with Heavy Eccentric and Lighter Concentric Loads

56. Sánchez-Medina, L., Pérez, C., González-Badillo, J.J. (Spain)
Acute Physiological and Mechanical Responses to Resistance Exercise Protocols Differing in Level of Effort

57. Raschner, Ch., Platzer, H.P., Patterson, C. (Austria)
Jump Performance in 11 to 18 Year Old Austrian Alpine Ski Racers – A 10 Year Longitudinal Study

58. Labudová, J., Matúš, I. (Slovakia)
Strength Skills of Synchronized Swimmers at Different Age

59. Zahálka, F., Malý, T., Malá, L., Čaba, L., Gryc, T., Hráský, P. (Czech Republic)
Comparison of a Football Goalkeeper's Lower Limbs´ Explosive Strength

13:00-14:00 Lunch

14:00-19:00 Social Program
(Trip to Small Carpathian Region - visiting Red Stone Castle
with wine tasting)

Saturday, October 30th, 2010

8:30-10:30 Mechanisms of Muscle Adaptation to Resistance Training I.
Moderator: Harald Tschan (Austria)

Goldspink, G. (London, Great Britain)
Molecular and Cellular Mechanisms Involved when Skeletal Muscle is Subjected to Active Stretch

Tihanyi, J. (Budapest, Hungary)
Does the Eccentric Exercise Down-Regulate Myostatin and Induce Muscle Fiber Proliferation?

Wessner, B., Tschan, H., Bachl, N. (Vienna, Austria)
Resistance Exercise Modes and Cellular Signaling Pathways in Skeletal Muscle

10:30-11:00 Coffee break

11:00-12:30 Oral Podium Presentations II.
Moderator: Truls Raastad (Norway)

Füle, R., Liu, Ch., Chen, Ch., Shiang, T. (Taiwan)
Effects of Passive Leg Press Training on Jumping Performance Speed and Muscle Strength

Kvorning, T., Frederiksen, L., Madsen, K., Nielsen, J., Gejl, K., Andersen, M. (Denmark)
The Effect of Strength Training and Testosterone Gel on Muscle Strength and Power, in Men Aged 60-78 with Low Testosterone Levels

Ahtiainen, J.P., Parviainen, T., Häkkinen, K. (Finland)
Resistance Exercise Training and Changes in Testosterone Production and Clearance Rate in Younger and Older Men

Vainshelboim, B., Alves, A.J., Goldhammer, E., Sagiv, M. (Israel)
Comparison of cardiopulmonary responses to Dynamic and Isodynamic Exercise Tests in Strength and Endurance Athletes

Váczi, M., Tihanyi, J., Rácz, L., Hortobágyi, T., Ács, P. (Hungary)
Strength Deficit Characteristics in Isometric and Stretch-Shortening Tasks Following a Single Bout of Damaging Exercise

Sedliak, M., Buzgó, G., Cvečka, J., Hamar, D., Laczo, E., Zelko, A., Zeman, M., Raastad, T., Nilsen, T., Ahtiainen, J.P., Häkkinen, K., Hulmi, J.J., (Slovakia)
Acute Responses in Muscle Hypertrophy Signalling to a Morning vs. Afternoon Resistance Exercise Protocol

Walker, S., Peltonen, H., Scaramello, C., Sautel, J., Avela, J., Häkkinen, K. (Finland)
Neuromuscular and Hypertrophic Adaptations Following Constant and Variable Resistance Training in Young and Old Men

Hagen, M., Lescher, S., Bruns, D., Gerhardt, A., Spichalla, S., Hennig, E.M., Felber, S. (Germany)
Biomechanical and Morphological Effects After Ten Weeks of Subtalar Joint Specific Pronator and Supinator Strength Training in Rearfoot Runners

Turbanski, S., Schmidtbleicher, D. (Germany)
Strength and Power in Wheelchair Athletes

12:30-13:45 Lunch

13:45-15:05 Mechanisms of Muscle Adaptation to Resistance Training II.
Moderator: Steven Fleck (USA)

Raastad, T. (Oslo, Norway)
Recovery of muscle function and cellular homeostasis after strength exercise protocols

Radak, Z. (Hungary)
Redox Regulation of Contracting Skeletal Muscle

15:05-15:30 Coffee break

15:30-17:30 A Sport Specific Approach to Strength Training
Moderator: Jószef Tihanyi (Hungary)

Schmidtbleicher, D. (Frankfurt, Germany)
Specific Strength Training – or How to Transfer Improvements of Strength Training into Functional Movements

Fleck, S. (Colorado Springs, USA)
Use of Chains and Rubber Cords in Weight Training

Hamar, D. (Bratislava, Slovakia)
Serial-Stretch Loading in Resistance Training

17:30-18:00 Announcement of International Scientific Committee of Conference Series on Strength Training

Questions and Answers

Closing Ceremony

20:00 Closing Banquet

Thursday 8:30-10:30

Physiology and Endocrinology of Resistance Training

PHYSIOLOGY OF RESISTANCE TRAINING: IMPLICATIONS FOR PROGRAM DESIGN

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INTRODUCTION

Resistance training spans a large number of different conditioning modalities that provide for external resistance. The important element of any resistance training program is the combination of acute program variables which dictate the specific exercise stimuli experienced by the activated motor units and their associated physiological systems needed for the performance of the workout. Key elements in an optimal resistance training program are related to the specificity of training, progressive overload, and optimal variation through a periodized training program.

ACUTE PROGRAM VARIABLES

For over a quarter of a century, the acute program variables have been utilized both in practice and research to further characterize a given resistance exercise protocol. These programs domain variables include, the choice of exercise, the order of the exercises, the number of sets, the length of the rest periods between sets and exercises, and the resistance utilized in the exercise. Different combinations of these particular variables result in differential physiological effects of various workouts. While within each domain numerous choices exist, understanding the impact of such choices is vital to understanding the physiology of the resistance training program which is chosen. The choice of exercise will dictate the musculature to be used and what controlling aspects will be operational. For example, choosing a squat exercise will require a greater degree of balance then choosing a knee extension exercise and recruit considerably more motor units in the body while of training the quad musculature due to its structural nature as an exercise. The order of exercise has also been the topic of attention from choosing large muscle groups first in the exercise protocol to optimize intensity to utilizing paired exercises to enhance endurance and muscularity in a push pull system. Probably one of the most important variables which has gained a great deal of attention both in research and commercial programs is a length of rest periods between sets of exercises. This particular variable is important in that short rest periods of less than 2 minutes can compromise the intensity of the exercise, exercise technique, and produce greater symptomatology related to nausea, dizziness, and even fainting in the process of trying to improve metabolic toleration and performances under high-intensity metabolic demands. The number of sets utilized in a resistance training protocol is what might be called a volume variable related increasing the amount of total work as a higher number of sets are utilized for a given muscle group or whole body workout. Ultimately, the intensity utilized in a resistance training protocol will dictate the motor unit requirement and therefore what muscle fibers are being trained in a particular protocol. Every other variable in the structure interacts to either promote or optimize motor unit recruitment. Therefore, the acute program variables stand as a crucial set of large domain variables which characterize any resistance training protocol.

UP AND DOWN STREAM REGULATORY ELEMENTS

The physiological interaction of any resistance training protocol or program is reflective of the type of workout in combination of acute program variables chosen. This particular element of exercise sits on top of a regulatory structure mediating both the physiological demands for homeostasis going down to the cellular interactions and genetic expressions. Attention to each of the upper regulatory elements which also include nutrition, environment, age, sex, and psychological elements dictate ultimately what messages are transmitted and what genes are expressed. The interaction of these upstream regulatory elements also help to further create characterize the stimuli which go downstream and what physiological systems are needed to support the physical demands of a workout. Often times characterization of these upper regulatory elements are not carefully quantified in research studies so as to leave the context of the findings unclear or ambiguous in their generalization or prescription. Nutritional aspects are especially important for understanding the adaptations to a particular resistance exercise protocol in that timing of nutrients, composition of the macronutrient array, and effective dietary programs all can influence both directly and indirectly training adaptations from a resistance training program. Environmental conditions are also important in that translation of training gains in strength, power, and local muscular endurance achieved in the resistance training program can be obviated if competition venues require thermal acclimatization. Age and sex also interact to determine both the magnitude of the responses to a training program. The psychological arousal can dramatically impact both hormonal and neurological function and in part dictate effects in both training and competition. Such upper regulatory elements are set up the context for the messages that are sent down the line to cellular receptors and gene expression while dictating what physiological support systems and to what extent they are needed to perform a resistance training protocol. In total the adaptations to any resistance training program will be the accumulated effects of both the exercise protocols utilized with their specific combinations of the acute program variables, periodized over time along with their interaction with other upstream regulatory elements that will dictate downstream cellular and genetic effects on target tissues.

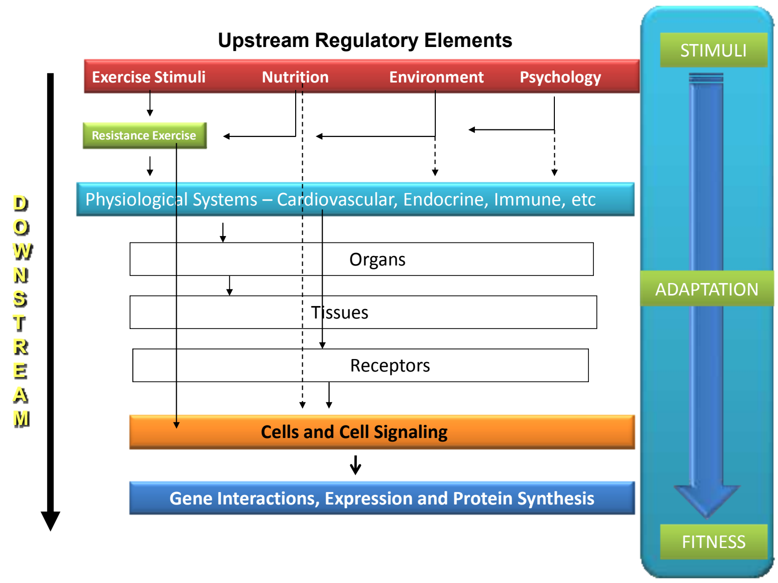

Figure 1. The upstream regulatory elements play a vital role in contextualizing the resistance training workout and training program as it relates to the downstream support of physiological systems and the demand on different organs and tissues leading to a host of cell signalling and receptor interactions culminating with genetic expression and protein synthesis of which is related to the neuromuscular systems adaptational effects.

MOTOR UNIT RECRUITMENT

The recruitment of motor units during a resistance training program impacts the adaptations that will occur. Based on "Size Principal" the intensity of the resistance exercise plays a vital role for how many motor units will be recruited. Furthermore, fatigue or loss of energy substrates will determine the effectiveness of the neuromuscular system in producing force. The motor unit array in each individual can vary significantly based on genetic predisposition. Furthermore each muscle in the body has a specific motor unit type and array and this too can affect the absolute magnitude of force production as well as the magnitude of training adaptations in the muscle fibers. Finally age and sex will impact the magnitude of gain as well as the loading requirements for adaptations. For example as we age, motor units can be lost. Typically these are the large Type II or units containing the Type II fibers leaving just Type I motor units. This can lead to what might be called a "compressed motor unit array" in which the intensity of a resistance exercise, e.g., 65% to 75% of the 1 repetition maximum, may not be very different in the number of motor units recruited when compared to 85% to 95% as many of the same motor units are producing the force over this continuum of intensities. Therefore, looking at training adaptations from only the perspective of muscle strength and muscle fiber size few differences may they be noted. However, this is in of muscle tissue and not necessarily connective tissue such as bone which responds to compression, strain and strain rate of which higher intensity will produce and thus differences occur between loading intensities. Smaller number of fibers in women's upper body will also produce a sex linked affect for lower amounts of force and power production as well as hypertrophy potential. Furthermore, Type I muscle fibers with their enhanced non-contractile bands and proteins needed to withstand the constant recruitment can resist muscle damage to a greater extent but delay recovery when dramatic damage occurs in this motor unit array. In addition, simultaneous training of both high-intensity oxidative and force production demands can dramatically compromise the ability of certain motor units, especially the Type I motor units to see protein accretion and power production with training. Therefore sensitivity to recovery and excessive oxidative influences of certain training programs are paramount to optimal adaptations. Therefore, the existing motor unit array in the individual muscles and what are predisposed in each individual plays a dramatic role in both the responses and magnitude of adaptations to a resistance training program.

HORMONAL AND CELL SIGNALLING

The genetic machinery are found in each cell is sensitive to a host of mechanical, nutritional, immune, metabolic, hormonal and cell signalling mechanisms related to the need for protein synthesis or degradation. With resistance exercise, again motor unit activation is vital in the process. What is important to understand is that most signalling systems are temporal and phasic. This is most important when considering the endocrine system which is made up of many anabolic signalling hormones which work to create adaptations in such variables that continued to increase over time.

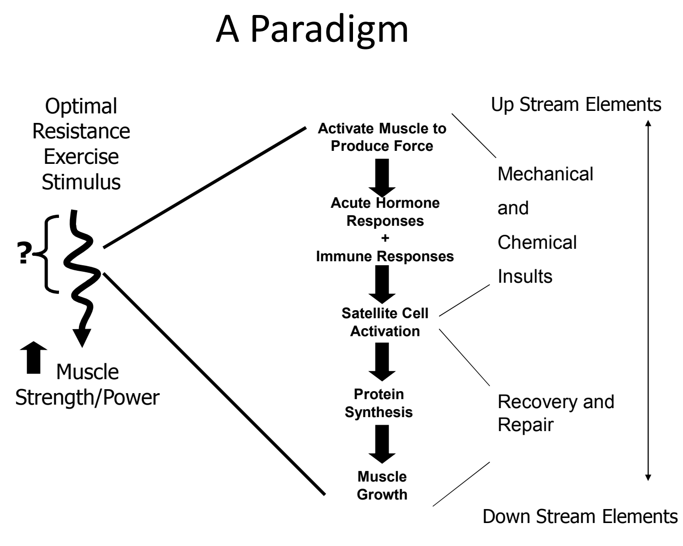

Figure 2. The optimal resistance exercise stimulus creates an activation pattern that relates to acute hormonal and immune responses down the regulatory chain leading to gene activation protein synthesis and muscle growth. This is but one array for a target tissue.

For example, while testosterone may be elevated in small molar amounts over a particular conditioning program, its real affect is related to the day-to-day increased elevation exposures to target tissues when the characteristics of the resistance exercise protocol permit. Furthermore, a branched chain amino acid, leucine, will have direct influence on the mTOR signalling mechanisms but only for the temporal time frame of its elevation in the body after ingestion. Interestingly, mechanical effects of muscular contraction can have a similar impact on this signalling system. Thus the redundancies and partitioning of the many anabolic signalling processes has been vital to evolutionary success as it relates to repair and remodelling of tissue, not just muscle. While the obvious target for resistance training is many times skeletal muscle and connective tissue, other systems such as the cardiovascular system, immune system, and endocrine system all have their own adaptations both within cells, tissues and glands making the array of adaptations spanning an entire range of physiology and dependent upon the type of program utilized. The genetic arrays mediating these many changes are both diverse and can be speculative at this point in time. However with genetic sequencing, the deep gene analysis, and improved integration of mitochondrial, bacteria, and organism gene analysis will allow greater insights over the next 10 years.

SUMMARY

The physiology of resistance training arising from a great deal of simplicity and misunderstanding over 100 years ago now continues to be expensive and mystifying in many regards as to the mediating mechanisms of adaptations. This is primarily due to the multitude of different training protocols that can be created and the wide physiological variability in subjects and athletes who benefit from this modality. Caution must be taken with regard to oversimplification of the exercise prescription process or the targeted requirements needed for specialized training populations. Fundamental resistance training principles have withstood the test of time but can be obviated by commercial expediency or academic frustration with complexity. The physiological effects start with the upstream regulatory elements in the composition of the resistance training protocol and their interactions leading to downstream signalling of adaptational results. Our understanding must not just focus on the endpoints of gene interactions but also the influences of the upper regulatory elements and program designs that dictate their response.

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Neural Control of Force Development During the Stretch Shortening Cycle

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Reactive Movements like walking, running, jumping and throwing play a major role in sports as well as during activities of daily living. During reactive movements power is much higher compared to all other types of movement. It has been suggested that enhanced power is related to the storage and utilization of energy within the muscles and tendons. A prerequisite to store kinetic energy in elastic properties is a specific leg or arm stiffness which is based, e.g. in the case of the leg, on the joint stiffness's of the ankle, knee and hip. Because passive stiffness's of these joints are far too low, active stiffening is crucial for high power and respectively performance. The aim of the present lecture is to provide detailed insight into the neural control of the muscles that are responsible for the active stiffening of the joints with special emphasis on those muscles encompassing the ankle joint.

Reactive Movements are characterized by a lengthening and a subsequent shortening of active muscle-tendon units. Norman and Komi (1979) called this combination "stretch-shortening cycle (SSC). In 1971, Melvill-Jones and Watt were perhaps the first who described the muscle activity during the SSC by means of surface electromyography (EMG) in human hopping. In line with other reactive movements the SSC during hopping is characterized by a reproducible muscle activity pattern of the triceps surae muscles.
Prior to touch-down, the leg extensor muscles are active in order to produce the required stiffness for storage of kinetic energy in elastic properties of the muscles and tendons. It has been demonstrated that pre-activity, quantified by the integration of the EMG prior to the ground contact, depends on the fall height in reactive jumps (Gollhofer 1987). It can be assumed that pre-activity is pre-programmed and its magnitude depends on the expected kinetic energy when hitting the ground. Thus, pre-programmed activity is defined as muscle activity that does not depend on the actual time of touch-down but on the expected time of touch down. Such a pre-programmed pattern has been seen in monkeys that jumped onto a false platform (Laursen et al. 1978). While the true landing was delayed in this paradigm, the EMG pattern remained time-locked to the time of the expected landing.
Approximately 45 ms after touch-down a consistent EMG bursts for the soleus (SOL) and gastrocnemii muscles (GAS) has been reported in various studies (Dyhre-Poulsen et al. 1991; Voigt et al. 1998; Funase et al. 2001; Taube et al. 2008). In these studies, the first EMG burst was suggested to be a stretch reflex response superimposed on activity from supra-spinal origin. This idea was based on the onset-latency of the first EMG burst, now commonly labeled short latency reflex (SLR), and the high excitability of the H-reflex at the time of touch-down. Recently, Zuur et al. (2010) showed that this burst is locked to the time of touch-down. They advanced or delayed the touch-down by shifting the height of a programmable platform up or down between two hops, without providing the subject clues about the position of the platform. The time shift in touch-down resulted in an equal time shift in the peak of the early EMG burst, thus demonstrating that afferent feedback triggered by ground contact contribute to the first EMG burst. In line with previous studies this first EMG burst was attributed to the SLR of a stretch reflex. Interestingly, in the experiments reported by Zuur et al. (2010) the authors were able to reduce the magnitude of this early EMG burst by inhibition of the motor cortex with sub-threshold transcranial magnetic stimulation (TMS), suggesting that the motor cortex also contributes to the first EMG burst.
After this first EMG burst a still segmented EMG follows and often two or three other bursts can be identified. These EMG bursts following the SLR are commonly named as medium latency reflex (MLR ~ 70 ms after touch-down) and long latency reflex (LLR, can consist of two bursts LLR_1 ~ 90 ms after touch-down and LLR_2 ~ 120 ms after touch-down). Recently, Taube et al. (2008) used TMS applied over the motor cortex in order to assess changes in the corticospinal excitability during reactive jumps. The authors reported no significant facilitation effects on motor evoked potentials (MEPs) superimposed on the SLR, MLR and

LLR_1 of the SOL. Only the LLR_2 was significantly facilitated which may indicate enhanced corticospinal excitability at LLR_2. Additionally the authors superimposed H-reflexes on the SLR, MLR, LLR_1 and LLR_2. The results show clearly facilitated H-reflexes in the early stance phase (SLR, MLR) which then decrease towards take off (LLR, LLR_2). The authors concluded that functionally, reduction in Ia-afferent transmission may help to enhance movement control and efficiency by preventing poorly timed muscular activation arising from spinal reflex circuits. It can be speculated that these late parts play a functional role in the postural control during the jump. In a study of Taube et al. (2007) the authors were able to demonstrate that after balance training cortical but not spinal excitability was correlated to improvements in stance stability. Therefore it can be speculated that those EMG bursts that are under enhanced cortical control are more important to correct for variations of the center of gravity during the execution of reactive jumps.

The results of the present study propose that cortical, spinal and presumably sub-cortical sources contribute to muscular activation during reactive jumps in a very time dependent manner. There is strong evidence that the first EMG burst after touch-down relies on afferent feedback, most likely from Ia-afferents, as indicated by a locked latency to the time of touch-down and facilitated H-reflexes at the time of the first EMG burst (SLR). Thereafter, the spinal contribution seems to progressively decline suggesting that other sources become more relevant. Since even the first burst can be influenced by inhibition of the motor cortex an ongoing cortical control is conceivable. However, the facilitation of MEPs during the LLR_2 (~ 120 ms after touch-down) may point to enhanced corticospinal excitability at the latest part of muscle activity during ground contact in reactive jumps.

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ACUTE AND CHRONIC NEUROMUSCULAR AND HORMONAL RESPONSES TO STRENGTH AND ENDURANCE MILITARY EXERCISES

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INTRODUCTION

Despite of the technological development, military operations and crises management are still very demanding and challenging for both individual soldiers and their leaders. Therefore, extremely good physical and mental preparedness are required for success in tasks during various environments. Namely, in military operations soldiers are often exposed to various stressors, not only prolonged and strenuous physical exercises but also energy and fluid deficiency, extreme ambient temperature, and sleep deprivation [11, 17]. During combat, the physical performance of soldiers can decline fairly quickly [22], and there is not enough time for maintaining or improving physical performance during increased operational tempo. Thus, soldiers should be at a high level prior to the beginning of operations. In addition, good physical fitness induced by regular physical activity plays an important role in promoting an individual's health.

Previously, it has been emphasized that endurance training is the most important factor for developing a successful soldier but currently the important role of strength training has recognized as well. In other words, a modern soldier needs both good aerobic and muscle strength capacity which enables work at a lower relative submaximal level during operations. However, in order to simultaneously improve aerobic fitness and muscle strength, periodization of training should be used in order to avoid interference of strength development induced by concurrent endurance and strength training as originally demonstrated by Hickson [5]. The purpose of this review abstract is to shortly describe acute and prolonged neuromuscular and hormonal responses to strength and endurance exercises in military environments.

PHYSICAL CHANGES DURING DEPLOYMENTS

Recent findings from a 13-month deployment in Iraq have shown that aerobic performance declined by 13 % ($p<0.001$) and fat mass increased by 9 % ($p<0.05$) in 73 combat army soldiers, while upper and lower body strength improved by 7 and 8 %, respectively ($p<0.001$) [9]. Among 110 infantry soldiers measured before and after the deployment to Afghanistan, declines ($p<0.01$) in peak VO_2 (-4.5%), medicine ball put (-4.9%), body mass (-1.9%), and fat-free mass (-3.5%) were observed, whereas body fat increased from 17.7% to 19.6% [22]. They also reported that lifting strength and vertical jump performance did not change. These both studies clearly demonstrate that 9-13 months deployments affect negatively aerobic capacity and body composition, while some positive changes can be seen in muscle strength.

CHRONIC NEUROMUSCULAR AND HORMONAL RESPONSES TO MILITARY TRAINING

During military training, physical fitness has also been reported to decline. The U.S. Army Ranger training of 8-weeks decreased ($p<0.05$) vertical jump height (-16%), explosive power output (-21%), maximal lifting strength (-20%), body mass (-13%), fat-free mass (-6%), and fat mass (-50%) [12]. Simultaneosuly, circulating total testosterone (TES) and insulin-like growth factor-I (IGF-I) declined ($p<0.05$), while cortisol was significantly increased. Nindl et al. [12] have also demonstrated that IGF-I and cortisol (COR), but not TES, were correlated with losses of tissue mass. In addition, heavy military field exercises lasting less than one week have been shown to induce increases in basal concentrations of circulating COR [14 - 17] and GH [16], and decreases in serum insulin (INS) [14], testosterone (TES) [3, 15, 16], and thyroid hormone levels [16, 17]. It has also been shown by Friedl et al. [2] that during a special 8-week ranger course, the amount of energy deficit (ED) is related to many of these hormonal changes. The 20-day field exercise supports those earlier findings: cortisol (COR, +32%) and growth hormone (GH, +616%) concentrations increased, while insulin (INS, -70%), total testosterone (TES, -27%), free testosterone (TESfree, -26%) decreased during the first week of training [8]. However, pre-post comparison revealed that no changes in maximal aerobic capacity or muscle strength of lower extremities were noticed while muscle strength of upper extremities and partly the abdominal and back muscles decreased (unpublished data).

While it is difficult or even impossible to maintain physical fitness during military operations, many nations have special training programs to improve soldiers' physical capacity before deployments. The U.S. Army has developed Physical Readiness Training (PRT), of which purpose is, especially, to improve physical fitness, prevent injuries, and progressively train soldiers [6]. They have compared PRT with a weightlifting/running program in an 8-week laboratory study, which shows that both programs resulted in major improvements in militarily relevant tasks but PRT consistently also resulted in fewer injuries.

Although some improvements in soldiers' physical performance due to physical training have been reported, little scientific research is available on the effects of concurrent endurance and strength training on the performance. A male weight-based training (WBT) and Army Standardized Physical Training (SPT) groups trained for 8 weeks, and results demonstrate that both SPT program and a weight-based training experimental program can improve similarly physical performance in military-related tasks [4]. However, Williams et al. [23] have found that a modified 11-week BT course, where strength training has been emphasized, resulted in greater improvements in military task performances. In a 12-week training study revealed a high degree of specificity when several combined training regimens were implemented [7]. In Israel, a 4-month gender-integrated basic training (BT) course reduced gender differences by approximately 4% in all tests except upper body strength [24]. An 8-week exercise training programs have been demonstrated to increase lean mass, aerobic fitness, and upper and lower body strength. However, bioactive or immunoreactive IGF-I as well as associated IGFBPs remained unchanged in serum [13].

A recent series of studies [18 - 21] have well shown that emphasized strength (ST) and endurance (ET) training programs combined with an 8 -week BT training improved not only VO_2peak but also muscle strength of leg and arm extensors by 9-12 % ($p<0.05$-0.001) and 13-14 % ($p<0.01$) in the ST and ET groups, respectively. However, the rate of force development did not change. Simultaneously, serum basal TES increased by 16-27% in both groups, but COR only in the ST group (11 %). Serum basal thyroxine concentration decreased by 11-12 % in both groups. In conclusion, for further development in muscle strength, the ST program combined with military training may require more periodization and individualization as well as decreases in the amount of endurance based military training.

ACUTE NEUROMUSCULAR AND HORMONAL RESPONSES TO MILITARY EXERCISES

Military training disrupts body homeostasis which can be evaluated, for example, by monitoring heart rate variability or analyzing changes in hormone concentrations. Acute increases in GH, TES and free TES concentration have been reported after bouts of dynamic concentric (CON) and eccentric muscle actions at the same absolute load trials, but only GH and lactate were greater for the CON trial [1]. A previous study [10] has partly shown the similar findings among young women. Significant increases following acute strength exercises were observed for TES (25%), free TES (25%), and SHBG (4%). In addition, adiposity correlated with testosterone concentrations. Recently, it has been shown that the 3K loaded combat run test increased acutely GH and TES concentrations while COR decreased [21]. At the same, maximal isometric force produced by the leg extensors decreased by 10-12% ($p<0.001$).

CONCLUSIONS

Naturally, the acute neuromuscular and hormonal responses to military exercises are similar to the respective changes induced by strength or endurance or their combined strength and endurance training. Fatigue weakens maximal neuromuscular performance in spite of increased androgen hormone concentrations. For improving both strength and endurance together with military training, it is a great challenge because endurance based military training interferes, especially, development of muscle strength. Finally, during deployments and crises managements, it seems to be almost impossible to maintain aerobic capacity for several months, which is an important information to commanders and instructors of training centers. Although several papers have been published on acute and chronic military exercises, new ideas are also needed to the creation of optimal training programmes during the deployment. For example, microcycle high intensity endurance training or strength training several times in a day could be one solution. However, more research is required in this field.

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Thursday 11:00-13:00

Strength Training and Aging

The Aging Neuromuscular System in Men and Women Still Responds to Systematic Strength Training

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Aging related decreases in muscle strength and power in men and women

Muscle strength and power decrease with increasing age accompanied with a steeper strength decline at the onset of the sixth decade in both men and women. The decrease in maximal strength from the age of 30 to the age of 80 years may be as large as 30 to 40 %. The decrease may be different between different muscle groups so that e.g. in the proximal muscles of the lower extremities it can be greater than that of the upper extremities (1).

The decrease in strength is largely related to the reduction in muscle mass, since aging is associated with alterations in hormone balance, especially with decreased androgen levels, and often also with a decline in the amount and intensity of physical activities. The decline in muscle mass is due to both a reduction in the size of individual muscle fibres, especially of type II fibres, and a loss of individual fibres (2). When some muscle fibres are permanently denervated and lost, a subsequent replacement of fat and fibrous tissue follows leading to a smaller proportion of muscle tissue in aging persons of both genders.

A decrease in maximal strength is also in part due to a decrease in maximal voluntary neural input to the muscles and/or changes in "qualitative" characteristics of the muscle tissue (3). Age-related decreased maximal voluntary activation of the agonists has been shown by an incomplete muscle activation during maximal voluntary efforts performed with the addition of supramaximal single pulses e.g. in the case of the quadriceps femoris (4). The incomplete muscle activation could in part be explained by an age-related decrease in the firing rate of motor units (5). In addition, there appears to be an age-related increase in antagonist coactivation, especially during dynamic actions (3). Nevertheless, the extent to which voluntary neural drive would decrease with increasing age is probably smaller than peripheral neuromuscular aging changes.

Aging leads also to large worsening in explosive force production whether recorded during dynamic actions by power and by the shape of the force-time curve. Actually, aging related decrease in explosive strength is even larger than that observed in maximal strength (3).

Aging related decreases in strength and power in master power athletes

Strength and power decline with increasing age also in master power athletes such as throwers who have carried out strength training over several decades. However, “lifelong” strength training seems to minimize strength decreases at all ages, since these male master athletes at the age of 75 years showed higher absolute strength values than untrained men at the age of 40 years both in the lower and upper extremity extensors (6). Elite master sprinters (40–82 yrs) also showed a gradual age-related decline in maximal dynamic and isometric leg strength as well as explosive dynamic strength and rate of isometric force development (7,8). When isometric force production was normalized to leg muscle cross-sectional area, the age-associated decline disappeared for maximal force but was still true for explosive strength. This slowing of isometric explosive strength is consistent with observations of age-related preferential atrophy of type II fibers. It is also possible that the deterioration in muscle function and associated neuromuscular properties are affected by a lack of proper strength training needed for effective stimulation of fast motor units.

Maximal and explosive strength and sprinting velocity of these master athletes was also compared to the values observed in the young adult athlete group (17-33 yrs) (8). In sprint-trained athletes age-related explosive strength declines of 10-11% per decade took place at a faster rate than that of 8-9% per decade observed in maximal strength. However, it was interesting that sprint performance, which is likely to impose higher requirements on the integration of muscle force production and neuromuscular coordination than strength tasks, was affected by age by 5% per decade in these sprinters. This supports the view of high training specificity and adaptability of the neuromuscular characteristics during aging, and that a large part of performance decline in older people is due to reductions in specific exercise stimulus rather than aging per se.

Neuromuscular adaptations during strength training in middle-aged and older subjects

Strength training induced gains in muscle strength in older people have been examined extensively since the late 1980s. Strength training leads to improvements in muscle strength independent of age and gender, when both the loading intensity of training and duration of the resistance training period are sufficient. However, large interindividual variation can occur in strength development caused by strength training especially in older people, in both men and women (9). Nevertheless, the gains in maximal strength during initial weeks of strength training are usually very large in previously untrained – in young adults, middle-aged and older persons – and may be largely accounted for by neural adaptations. This can be measured e.g. using specific recordings of voluntary actions combined with electrical stimulation procedures or using invasive techniques, in which needle or fine-wire electrodes are inserted into muscle, H-reflex and V-wave measures, evoked cortical potentials or by analyzing changes occurring in EMG activity of trained muscles during maximal voluntary actions. Although the EMG is a complicated signal, subject to various sources of errors and represents only an average of the maximal neural activation of the muscle, the increase in the quantity of EMG suggests that the number of motor units recruited have increased and/or motor units are firing at higher rates or a combination of the two has occurred. Resistance training leads to changes in the quantity and quality of activation so that 1) activation of the agonists is increased (increase in efferent motor drive; increased motor unit firing frequency; enhanced motor unit synchronization; increased motoneuron excitability; down regulation of inhibitory pathways), and there is 2) an improved coactivation of the synergists and 3) a reduction in coactivation of the antagonists (10). Older subjects may show large interindividual variation in increased voluntary activation of the agonists during strength training (4, 11). Furthermore, strength training can lead to reduced coactivation of the antagonist muscles, especially in older subjects (11) enhancing the net strength production of the agonists. Strength training in aging persons leads not only to increases in maximal and explosive strength of leg extensors but also to improvement in their walking speed and dynamic balance capacity (12).

The degree of strength training-induced hypertrophy can be measured by analyzing the size of individual muscle fibers or by analyzing the cross-sectional area of the muscle by a means of US, CT or MRI. Muscle hypertrophy has accounted for the strength gains even in very old subjects both in the lower (11, 13, 14) and upper extremities (15). The increase in muscle CSA during strength training comes primarily from the increase in size of individual muscle fibres of both type I and II, probably with no addition in fibre number. Strength training-induced muscle hypertrophy in older men and women seems to take place both in subtype IIa and IIb fibres (14, 18). High tension of a muscle for a sufficient duration somehow provides the signal for increased uptake of amino acids and enhanced synthesis of contractile proteins. The repeated process of damage and repair during and between training sessions may result in an overshoot of protein synthesis. In addition, type II subtype transformation going from type IIb to IIab to IIa has been previously observed in younger (17) and older men (18) but not necessarily in older women (14). The role of duration and mode of resistance training in muscle fiber transformation in type IIb fiber population needs further examination. The magnitude of the increases in the sizes of individual muscle fibres does not necessarily correspond to the enlargements recorded in the CSA of trained muscles. Nevertheless, average enlargements in the total muscle CSA may be as large as 10 % after 2-4 months of strength training in both middle-aged and older men and women.

Neuromuscular adaptations during strength training in master power athletes

Age-related decreases occur not only in maximal strength but muscle CSA of the leg and arm extensors decrease with increasing age among master throwers (6). However, these athletes showed almost similar CSAs at the age of 75 years compared to untrained men at the age of 40 years. The results show the high trainability of muscle mass even at older ages. Furthermore, the finding that maximal strength per muscle CSA of leg extensors did not change with increasing age among master throwers, and that this ratio was higher than in untrained age-matched men indicate that maximal voluntary muscle activation can be maintained high by strength training even in older age (6). The higher firing frequency of motor units observed in master weightlifters at the age of 67-79 years compared to age-matched untrained older men supports this suggestion (5).

A recent study (19) showed that incorporating weight training exercises into the overall training for 20 weeks led to considerable improvements in maximal and explosive strength in world-class master sprinters (52-78 yrs). Part of the explanation for the substantial improvements in strength may be due to the specific form of strength training used, in which heavy resistance exercises were combined with explosive types of weight training and plyometric exercises. The strength gains may also reflect successful periodization of training to maintain overall training loading within the normal physiological range. These older athletes also produced higher ground forces with shorter contact times in response to the training program, leading to an increase in the rate of force development. The gain in muscular strength could improve the stretch-shortening cycle capacity in running by allowing the leg extensor muscles to withstand greater impact loads and enhancing the force performance potentiation in the propulsion phase of the contact. Maximum 10-m running speed in these master sprinters improved by 4%, and stride length of the maximum speed phase increased by 3% but no significant change occurred in stride rate.

These elite master sprinters showed a 10 % improvement in squat jump which was accompanied by a significant 9% increase in the iEMG of the agonist leg extensors (19). The increased iEMG response in the initial movement phase of the squat jump suggests adaptations in the rapid neural activation of motor units. Increased EMG development at the onset of a muscular contraction has been observed in previous strength training studies in young and older adults (11, 20). This may reflect adaptations in the motor unit recruitment pattern e.g. earlier motor unit activation, increased firing frequency and brief interspike intervals (doublets) in the EMG burst. Interestingly, the increases in maximal isometric knee extension torque as well as dynamic 1-RM squat were not accompanied by a significant change in the maximum iEMGs of the agonists (19), suggesting that the addition of strength training stimulus in already sprint-trained athletes may not lead to increases in neural drive during maximal slow concentric and isometric contractions.

The 20-week training program, which included both sprint and heavy-resistance & explosive strength training exercises, was accompanied by muscle hypertrophy, with significant increases in the CSA of type II fibres (19). These findings support the effectiveness of this specific training regimen and also point out the contribution of hypertrophic factors to maximal and explosive strength development in elite master sprinters. This training study in elite master sprinters at the age of 52-78 years provided new information, independent of deconditioning effect, on the plasticity of the neuromuscular system in older age. Strength training containing both heavy resistance and lower load high-power exercises may be effective in preventing fast fibre atrophy and loss of explosive force production, which are critical changes in the normal aging process.

Hormonal responses and adaptations to strength training in older subjects

Resistance exercise elicits an acute hormonal response modified by the protocol (intensity, volume, muscle mass involvement, rest interval etc.), training background, age, gender, and nutrition etc. The acute response may be more critical to tissue growth and remodeling than chronic changes in resting hormonal concentrations, since several studies have not shown changes during resistance training despite muscle hypertrophy and increases in strength. Nevertheless, adaptations to resistance training entail four general classifications: 1) acute changes during and post-resistance exercise, 2) chronic changes in resting conditions, 3) chronic changes in the acute response to resistance exercise, and 4) changes in receptor content (21).

Blood concentrations of circulating anabolic hormones and growth factors are diminished with aging. However, when the overall volume/loading of strength training remains within normal physiological range, strength can be increased throughout the 6-month training period with no systematic changes in the serum concentrations of anabolic and catabolic hormones (14, 22). Second, although a basal level of the anabolic hormone testosterone is lowered especially in older women, they seem to be able to gain in strength to about the same extent as middle-aged or young adults when utilizing a similar type of low volume total body strength training protocol over the 6-month period. However, in those older women who have showed low basal testosterone levels, the individual gains in both maximal strength and CSA of the trained muscles during strength training may be minor in comparison to those with higher testosterone concentrations (14). Basal concentrations of blood testosterone may be of great importance, even so, that a low level of testosterone may be a limiting factor in older women, for both strength development and training-induced muscle hypertrophy, when typical total body heavy resistance training programs are utilized. Strength training can induce changes at the receptor level (21), and more information is needed on hormonal adaptations including expression and contents of androgen receptors and interaction between hormones and hormone receptors during strength training.

In addition to the aging related decrease in basal concentrations of circulating anabolic hormones the acute anabolic hormone response to heavy resistance loading decreases due to aging in both men and women, especially around the age of 70 years (18, 22, 23). Interestingly, no significant acute loading induced increase was observed in older women in serum GH levels before training, but after the 21-week strength training period the acute loading response in serum GH in these older women (64 yrs) became significant (22). Due to the pulsative nature of GH secretion the interpretation of single measures must be done cautiously. However, this observation may be an indication of the training-induced adaptation of the endocrine system showing that the acute GH hormone response may become more systematic after strength training even in older women. The magnitude and time duration of the acute GH hormone response may be important physiological indicators of anabolic adaptations during strength training even in older women.

Conclusions

The aging neuromuscular system in men and women responds remarkably to systematic strength training. It should be recommended as an important part of an overall physical training program to maintain functional capacity of older persons at as high a level as possible for as long as possible. Total body resistance training is recommendable but special attention should be paid to strength and explosive force production of the leg extensor muscles due to their important contribution to several tasks of daily life. The benefits of maintaining or improving strength and power in aging people include correction of gait disturbances, prevention of falls, improved stair climbing and walking, improved performance of activities of daily living, increased capacity of independent living and delayed threshold of dependency. Strength training of aging people can be utilized as a preventive, therapeutic, and rehabilitative tool to optimize neuromuscular function and enhance performance. Among master athletes proper attention should be paid to both maximal strength and power training of important muscle groups to optimize the athletes' performance in their event.

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Skeletal muscle stem cells and muscle regeneration: Effect of ageing

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Age associated loss in skeletal muscle mass, strength and function is mainly due to an imbalance between protein synthesis and proteolysis, that is influenced by several factors of which anabolic resistance to feeding, diminished growth factor stimulation, and low grade inflammation are prominent ones. In addition, muscle regenerative capacity declines and the amount of connective tissue in supporting tissue like tendon reduces with ageing resulting in more loose and compliant matrix (1). The reason for this is unknown, but in vitro data from cell cultures on muscle stem cells (satellite cells) (2) and on tendon fibroblasts (3) indicate that the intrinsic-embryonic activity of the cells are intact in old age, and that environmental milieu hormones and growth regulating factors may inhibit or diminish the intrinsic cell activity, and thus drive the age related decline in tissue function.

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LONG-TERM ADAPTATIONS IN MIDDLE-AGED AND OLD SUBJECTS ATTENDING A SUPERVISED EXERCISE PROGRAM

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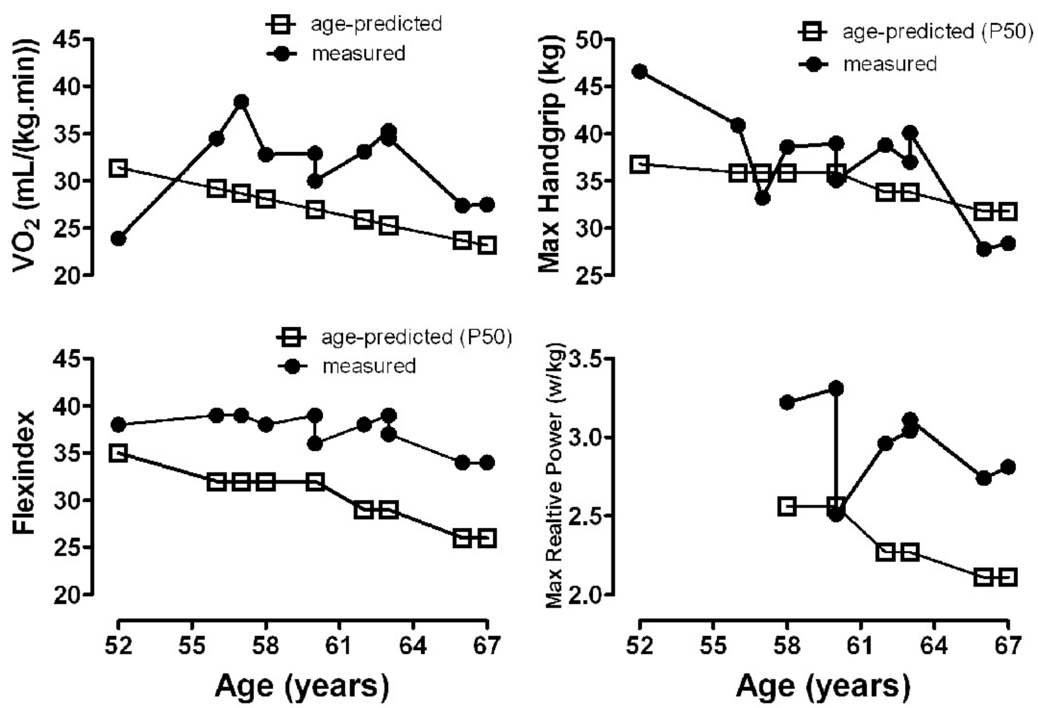
It is well-known that regular physical exercise provokes physiological adaptations that favourably influence both life expectancy and health-related quality of life. Notwithstanding, the vast majority of exercise intervention studies are very short, typically lasting eight to 12 weeks of two-five exercise sessions/week, resulting in about only 20-36 exercise stimulus. Considering a public health-oriented perspective, it is of upmost importance that healthy exercise pattern and habits be followed along the life and not just by a few weeks or a couple of months. In this context, how is possible to assume that a given short-term intervention protocol providing better results will still work similarly in a long-term and a more desirable setting, such as years or decades? Based in our 30-year clinical experience with medically-supervised exercise programs (MEP), the major aim of this lecture is to discuss the adaptations in some major aspects of physical fitness – aerobic, strength/power and flexibility – that are seen with long-term exercise interventions.

From 1994 to mid-2010, about 1750 subjects (60% men) participated in our private MEP, comprising over 260,000 hours of exercise. Subjects entered the MEP had identical mean and median ages of 61 years, ranging from 9 to 98 years old. Most of them were referred to MEP by their assistant physicians due to known coronary artery disease. The median MEP participation time was about six months (range: 1-194) and the number of individual exercise sessions ranged from 1 to 3756, with a mean of 147 and a median of 46 sessions. Over five-year attendance was found in 5% of the subjects. For practical purposes of the scope of this lecture, we selected data from two age-groups: middle-age (45-65 years old) and old (66-100 years old). At the MEP entry, all subjects were submitted to a detailed medical-functional evaluation that included: anamnesis & physical exam, resting spirometry and ECG, anthropometric appraisal, muscular strength (handgrip), maximum power (half-row exercise) and flexibility (Flexitest - 20 body movements) evaluations, a 4-s exercise testing for cardiac vagal tone assessment were followed by a maximal cycling cardiopulmonary exercise testing (CPX) performed in a ramp protocol. Measured maximum aerobic power was compared to predicted data for age and gender specific equations for cycling maximal testing. Other physical fitness data were compared to large (minimum 1,000) age-gender reference data obtained from our laboratory and results expressed in percentiles In about 1/3 of the subjects, we were able to obtain data from at least one complete reavaluation using the same testing protocol.

The MEP sessions typically lasted one-hour and involved a brief medical check before a 30-min of individually-prescribed (based on anaerobic threshold obtained during CPX) aerobic type exercise – lower and upper limb cycling, treadmill /running treadmill and rowing -, 10-15 strengthening exercises in 2-3 series of 5-8 repetitions carried out as fast as possible during concentric phase at the maximal power load (as previously measured by Fitrodyne) and individually-prescribed stretching exercises (based on Flexitest results) is performed. Balance, coordination and respiratory exercises could also be included as needed. During exercise sessions, permanent HR monitoring and intermittent blood pressure measurements are regularly made. ECG and SaO2 are monitored as directed by the MEP' supervising physician.

The most remarkable finding of this preliminary analysis of our data is that typical age-related decline in all components of physical fitness can be properly counteracted by regular attendance to a MEP in most of the subjects. Notwithstanding, some peculiarities regarding age-group and gender are seen in the magnitude of the long-term exercise intervention effect for the diverse components of physical fitness and will be detailed during the lecture. Data from nine complete evaluations from a 52 year-old male subject submitted to a coronary artery bypass graft along a 15-year period of time are shown below for illustration.



Friday 8:30-10:30

Enhancement of Strength Training with Nutrition and Technology

The Effect of Carbohydrate/Protein Supplementation on Training Adaptation

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INTRODUCTION

Following an intense exercise bout, the body is primarily in a catabolic state. Stress hormones such as cortisol are elevated, and key fuel stores such as muscle glycogen are low or even depleted. For recovery and positive adaptations to occur at the most optimal rate, a shift must be made from this catabolic state to an anabolic one. Ingesting the proper post-exercise nutrition and doing so with optimal timing, is critical for this desirable transition to occur.

Nutritional supplementation post-exercise is effective for several reasons. Immediately after exercise, the sensitivity of muscle to nutritional stimuli is heightened, remaining maximally elevated for approximately 30 - 60 minutes. Ingesting nutrients during this time optimizes the rate at which muscle glycogen can be replenished and muscle protein synthesis can be activated. In addition, nutrients can attenuate the catabolic stress hormone response (25) and can help prevent additional protein breakdown (4), thereby accelerating protein accretion. The combination of protein and carbohydrate is more effective than either macronutrient alone because they each activate different but cooperative signaling pathways that serve to regulate carbohydrate and protein metabolism. Enhanced muscle glycogen storage and protein accretion leads to faster recovery and increased muscle mass and strength – key goals of any resistance training program.

However, a daily nutrition plan should also be developed. This plan should describe when to eat, how many calories to consume and the macronutrient composition of each meal and snack. Such detail to daily nutrition should foster recovery and enhance training adaptations over the course of a prolonged training program.

MUSCLE GLYCOGEN

While the importance of muscle glycogen is often discussed in the context of endurance exercise, this fuel source is critical for resistance exercise as well. Muscle glycogen stores can be significantly depleted after an intense resistance exercise bout (15), and it is important that glycogen is restored before the next bout to ensure a quality workout. If recovery is more effective, then it is conceivable that the training load can be increased at a faster rate for greater training adaptation.

It has been demonstrated that providing a carbohydrate supplement immediately post-exercise results in a doubled rate of glycogen synthesis compared to providing the same supplement 2 hours post-exercise (16), and that carbohydrate intake greater than 1.5g$\bullet$kg^{-1} body wt will maximize muscle glycogen storage when provided at 2-hour intervals (17). The addition of more calories will not continue to increase the rate of muscle glycogen resynthesis. In fact, providing 3.0g CHO$\bullet$kg^{-1} body wt immediately post and 2 hours post exercise versus 1.5g CHO$\bullet$kg^{-1} demonstrated the same effect on muscle glycogen resynthesis during a 4-hour recovery period (17). However, it has been shown that more frequent supplementation such as every 15 to 30 minutes results in rates of synthesis 25-30% higher than when supplementing every two hours (10, 34). The amount of carbohydrate necessary to maximize glycogen storage when supplementing frequently (1.5g/kg body wt•h^{-1}) is twice that shown to be most effective when supplementing at 2-hour intervals (0.75g/kg body wt•h^{-1}). This high amount of carbohydrate could easily be considered excessive for many people to ingest, and the high frequency of supplementation does not reflect a practical post-exercise strategy.

A more practical approach for most exercisers and athletes is to ingest a supplement immediately post-exercise, and about 2 hours later. A strategy that addresses the practicality of daily training or competitive events, and that maximizes muscle glycogen restoration, is much more attractive and useful. Rather than provide large boluses of carbohydrate, research suggests that a more moderate amount of carbohydrate with the addition of a small amount of protein can be provided instead. In fact, such carbohydrate plus protein supplementation has been shown to increase muscle glycogen resynthesis post-exercise to the same extent as when supplementing frequently with high amounts of carbohydrate (2, 18, 38). The amount of carbohydrate and protein found to be most effective ranges between 1.2-1.5g CHO•kg^{-1} body wt and 0.4-0.6g PRO•kg^{-1} body wt when provided immediately post exercise at 2-hour intervals. For individuals engaging in resistance exercise training, however, the amount of carbohydrate can be reduced to 1.0-1.2g CHO•kg^{-1} body wt, because carbohydrate stores are not as greatly depleted in resistance exercise as occurs with prolonged endurance exercise.

MUSCLE DAMAGE

Muscle damage associated with resistance exercise occurs from the mechanical stress placed on the fibers during the eccentric phase of contraction (6, 12) as well as the catabolic hormonal environment that increases muscle protein breakdown post-exercise. When no supplement is provided post-exercise, this catabolic environment predominates, with muscle damage continuing to increase for many hours. In addition, muscle glycogen resynthesis has been shown to be impaired in damaged muscle (8, 35), limiting glycogen recovery for several days.

Recently, Baty et al. (1) reported that supplementing with a carbohydrate-protein supplement before, during and immediately after resistance exercise reduced the appearance of myoglobin and creatine phosphokinase (CPK) in the blood that occurred during and following exercise. These proteins are found in skeletal muscle and leak into the blood circulation when muscle damage occurs. The results of Baty et al. (1) suggest that carbohydrate-protein supplementation can limit muscle damage that occurs both during as well as in the hours after the exercise bout. An earlier investigation by Wick et al. (37) reported a trend ($p<0.08$) for lower CPK with a milk-based carbohydrate-protein recovery supplement versus a carbohydrate only beverage following resistance exercise, although no difference in inflammatory markers or in muscle function was reported.

Other investigations using endurance exercise models have demonstrated reduced muscle damage in response to carbohydrate-protein supplementation compared to carbohydrate alone or placebo (7, 27-30). Recently, Valentine et al. (33) investigated the responses of trained cyclists to carbohydrate versus carbohydrate-protein supplements. The cyclists performed an intense cycling bout to fatigue while receiving the treatments during the bout. Following a 24-hour recovery period the cyclists performed a resistance exercise session consisting of leg extensions to fatigue. Not only was time to fatigue during the cycling exercise longer during the carbohydrate-protein treatment, but the number of leg extension repetitions performed to fatigue 24-hours later was significantly greater, compared with the carbohydrate or placebo treatments.

The authors also reported a significant decrease in markers of muscle damage with the carbohydrate-protein supplement after the cycling bout (33).

PROTEIN SYNTHESIS

An increase in mixed muscle protein is at the very heart of exercise training adaptation. While resistance exercise is associated with hypertrophy of skeletal muscle fibers, endurance exercise is primarily associated with increases in mitochondrial protein. Thus, both types of exercise stimulate mixed muscle protein synthesis, albeit with an exercise phenotype-specific response (36). For the purposes of this presentation, the focus will be primarily on the response to resistance exercise, while drawing insight from endurance studies where applicable.

While an acute bout of resistance exercise increases muscle protein synthesis above the basal rate, it also increases the rate of protein degradation. The balance between degradation and synthesis determines net protein balance, and for strength and mass gains, creating a positive protein balance is essential. Unfortunately, a negative net balance predominates until nutritional intake occurs following a resistance exercise bout.

It has been shown that the addition of adequate protein, especially the essential amino acids, to a post-exercise carbohydrate supplement is vital for optimizing protein synthesis, creating a positive protein balance, repairing muscle damage, and stimulating training adaptations (3, 9, 13, 14, 20, 22, 26, 32). In addition, carbohydrate-protein can reduce muscle protein breakdown, largely due to an increase in plasma insulin levels. Insulin is one of the body's most anabolic hormones, and exerts its most powerful effect by reducing protein degradation post-exercise (4, 5). When a supplement containing protein or amino acids is provided post-exercise, net protein balance shifts because the rate of synthesis can now exceed that of breakdown (32).

Elevating plasma amino acid levels post-exercise by infusion or oral supplementation has been demonstrated to shift the protein balance of the muscle from negative to positive by stimulating protein synthesis (26). Investigations by Levenhagen and colleagues (22), as well as Miller et al. (23), have demonstrated that the combination of carbohydrate and either protein or amino acids can in fact have an additive effect (22, 23), which is likely due in part to a synergistic effect on the plasma insulin response (31, 38), and elevated plasma amino acid levels. When amino acids are available, insulin may have an enhanced stimulatory role in protein synthesis (24), yet its most important role in facilitating a positive net protein balance appears to be in reducing degradation (4).

Given that amino acids stimulate protein synthesis, and an increased plasma insulin level reduces protein degradation, the combination of carbohydrate and protein in supplementation can result in a more positive net protein balance. This is due to the synergistic action of carbohydrate and protein on two different but cooperative pathways (19, 24). Carbohydrate ingestion activates the insulin-signaling pathway, while the amino acids in protein engage the mTOR pathway. These pathways converge to increase both muscle glycogen synthesis as well as activate mRNA translation initiation, which is the rate-limiting step leading to protein synthesis.

Just as skeletal muscle is most sensitive to insulin and nutritional substrate for glycogen resynthesis immediately post-exercise, stimulation of protein synthesis by amino acids is most responsive immediately after exercise as well. Levenhagen and colleagues (21) provided a carbohydrate-protein supplement either immediately or 3 hours after a moderate-intensity cycling exercise bout and found that whole body protein synthesis was increased 300%, compared to only 12% when the supplement was delayed by 3 hours (21).

In studies of resistance training over several weeks, carbohydrate-protein supplementation has been shown to increase muscle mass and strength development when taken nearer to the start or end of resistance exercise sessions as opposed to providing the supplementation several hours before or after exercise. Cribb and Hayes (9) demonstrated that a significantly greater increase in muscle mass and strength could be achieved during 10 weeks of resistance training if a carbohydrate-protein plus creatine supplement was ingested before and immediately after each daily workout, as compared with providing the supplement in the morning and at night. This agrees with previous findings of Esmarck and colleagues (11), who investigated the effects of providing a carbohydrate-protein supplement either immediately post-resistance exercise or delaying it by 2-hours in a group of elderly males. They found a significant increase in muscle mass and in dynamic and isokinetic strength when the supplement was provided immediately post-exercise, whereas only a small increase in dynamic strength was observed in the group ingesting the supplement 2-hours post-exercise (11). Moreover, we have found that providing a post exercise carbohydrate-protein supplement results in a greater increase in muscle mass and strength than providing a carbohydrate supplementation over the course of 16 weeks of training (unpublished observation). Given that increasing muscle mass and strength are the primary goals of a resistance training program, it seems clear that supplementing with carbohydrate plus protein after each training session is the most effective and advantageous way to accomplish these goals.

DAILY MEAL PLAN

A daily nutritional program should provide the appropriate number of calories and composition of macronutrients that will accomplish one's goals over the course of the day as well as through the different phases of one's training program. The macronutrient composition of one's diet should change throughout the day according to the body's needs. For example, carbohydrate is very important in the morning hours, while protein is not. Conversely, protein and fat are more important in the late afternoon and early evening, whereas carbohydrate is not. Therefore, breakfast should be high in carbohydrate and low in protein, while dinner should consist of a high percentage of protein and fat and low percentage of carbohydrate. For increasing strength a positive caloric balance of 100 to 150 calories per day is recommended. For increasing muscle mass and weight, daily caloric consumption should exceed caloric expenditure by 300 to 500 calories. However, if the goal is fat reduction, the carbohydrate composition of the diet should be reduced and the protein content increased, while the overall caloric balance should be a negative 100 to 300 calories per day. Overall the recommended protein requirement for resistance training is 1.6 to 2.0 $g/day \bullet kg^{-1}$ body weight.

CONCLUSION

In summary, while resistance exercise stimulates muscle growth, the process of muscle protein accretion is greatly limited until nutritional substrate is provided. In the absence of supplementation, a catabolic state predominates and net protein balance is negative. Providing carbohydrate-protein supplementation immediately and 2-hours post exercise can increase the rate and amount of muscle glycogen replenishment, reduce muscle damage, and increase the rate of muscle protein synthesis to a greater degree than providing carbohydrate or protein alone. Carbohydrate plus protein supplementation leads to greater gains in muscle mass and strength, which is the overarching goal of resistance training programs. Additionally, much can be gained by developing an appropriate daily nutritional plan.

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Tschan, Harald, Bachl, Norbert.

Resistance Exercise Training to Counteract Muscle Atrophy and Strength Loss in Long Term Spaceflight”

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Background: To this day, the effectiveness of each manned mission to space depends on the health and exercise performance of each crewmember. With increasingly longer missions and complex extravehicular activities, crew functioning could be limited by muscle wasting and muscular weakness. At the Earth’s surface gravitational loading acts on all masses defining the weight of each object. Therefore throughout evolutionary history on Earth the human body has been designed to bear weight. In a microgravity environment, the amount of muscular force required to produce locomotor activity is small enough to lie in the domain of inactivity. There is a lack of static loads and a drastic decrease of dynamic loads (loss of functional weightbearing) in the neuromuscular system in space, resulting in rapid and considerable loss of muscular capacity. Without appropriate equipment to counteract the deleterious pathophysiological effects of microgravitational deconditioning, and without appropriate means to measure astronaut on-orbit muscle performance capabilities the safety of interplanetary travel will be severely restricted. If humans are to complete exploration missions to the Mars, countermeasures to the human health challenges of microgravity exposure will need to be in place prior to these missions. The challenge lies in the design and development of exercise equipment and in-flight protocols that will prevent or minimize these deleterious sequelae of long-duration missions while maximizing valuable on-orbit crew time.

Aim: The aim of the Austrian – Russian “Motomir-Project” accomplished during space station Mir flights in the 1990s was the development of a dynamometer to assess the extend and temporal pattern of changes in human skeletal muscle strength of the upper- and lower extremities during and following space missions. Based on the results and experiences of this project a new exercise device the Multifunctional Dynamometer for Application in Space (MDS) has been developed and is currently used in the Mars500 isolation chamber experiment a terrestrial cooperation project between European Space Agency (ESA) and the Russian Institute for Biomedical Problems (IMBP). The purpose of the Mars500 study is to gather data, knowledge and experience to help prepare for a real mission to Mars. Obviously there will be no effect of weightlessness, but the study will help to determine key psychological and physiological effects of being in such an enclosed environment for such an extended period of time and help to check stability and susceptibility to failure of this exercise and diagnostic equipment.

Methods and Results of the "Motomir Project" - Retrospect: Within the "Motomir Project" the force generating capacity of 8 male cosmonauts was assessed not only pre- and post-flight, but also during one short-term mission (9 days) as well as during 5 different long-term space missions (127-438 days). The results of these research demonstrate that space travel results in a significant and exponential decrease of muscle strength of the lower extremities when compared to pre-flight baseline values (p<0.001 - p<0.0001). Strength decrements were more pronounced in extensors (41.9±8.7% concentric mode) compared to flexors (27.7±9.1% concentric mode). These progressive losses were comparable throughout the different muscle action types (concentric, eccentric and isometric). In upper extremities changes in muscle strength were not that substantial, and no difference between extensor and flexor muscles could be detected. A single cosmonaut however, additionally using the Motomir dynamometer as an in-flight resistive exercise device every third day during his 175 days mission demonstrated that high intensive strength type of exercise was effective in maintaining muscle strength and function. Although the endurance oriented exercise countermeasure program performed aboard space station Mir flights usually had been successful in preserving endurance capacity, this form of exercise was only partlially effective in maintaining muscle size and function. This suggests that additional exercise having a larger resistance element may prove beneficial to protect skeletal muscle and bone health of crewmembers during spaceflight.

MDS Project - Prospect: Based on these findings MDS was designed as a computerized, velocity-controlled exercise training- and measurement device (Angeli et al. Technical University Vienna) allowing to perform concentric and eccentric muscle actions in a variety of resistance exercise programs that target a broad variety of different muscle groups (e.g. squat, leg press, dead lift, calf raise, bench press, lat pull, biceps curls, back extension, abdominal exercise). The resisting power for these exercises is provided by an electric motor thereby force, position and speed of the training performed can be well-regulated for different modes of training using a touch screen which can be operated by the user. Force applied and position of the training bar is measured by load pins and a rotary encoder. Relevant training data are displayed on the screen and stored for further analyses. First terrestrial training studies demonstrate that this form of training was equally effective compared to training using free weights.

Acknowledgments and Grants: *MDS has been developed as a cooperation project between the Faculty of Sport Science, Dept Sport and Exercise Physiology, University of Vienna / Austria (N. Bachl, H. Tschan & R. Baron), the Institute for Engineering Design and Logistic Engineering – Machine Design and Rehabilitation Engineering, Technical University Vienna / Austria (T. Angeli, N. Barta, G. Adamcik & R. Talla), and the Institute of Biomedical*

Problems of the Russian Academy of Sciences, Moscow, Russia (IB Kozlovskaya, A Netreba, A Shpakov & E Tomilovskaya) with generous financial support from the University of Vienna and FFG.

A REAL TIME FEEDBACK AND MONITORING OF SPEED AND POWER IN RESISTANCE TRAINING FOR ATHELETES

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INTRODUCTION

In designing resistance training programs and evaluations of strength capabilities for athletes, a great deal of attention has long been directed mainly to only mass itself and number of repetitions. It's true that speed and power have been considered as key factors in development of athletic abilities and performance, and that explosive exercises (clean, snatch, and jump squat etc.) have often been prescribed as particular exercises which are supposed to improve speed and power. However, speed and power actually produced by athletes in each resistance training sessions unfortunately have been neglected and out of control, even though a great deal of scientific knowledge on speed and power in resistance training has been accumulated. In order to optimize resistance training, program variables should be objectively manipulated by coaches and athletes [1]. Luckily, a number of technologies which can be used to know speed and power actually produced by athletes in resistance training session are now becoming increasingly prevalent. Coaches and athletes are able to control resistance training sessions more effectively using the information offered from these devices.

TECHNOLOGY TO OBTAIN SPEED AND POWER IN PRACTICAL RESISTANCE TRAINING SESSION

Linear position transducers

A linear position transducer (LPT) is one of the common device which measures displacement by linear or rotary encoders using optical or electrical signals with cables connected to resistance training equipments such as barbells. Once we have displacement, velocity is calculated from the formula "velocity=displacement/time". Acceleration is again calculated by "acceleration= velocity/time". Force can be calculated as multiplication of mass lifted and the sum of gravitation ($g=9.81m \cdot s^{-2}$) and instant acceleration obtained from the calculation, therefore "Force=mass・(gravity+acceleration)". Power is calculated by "power=force×velocity". Some type of LPT directly measure velocity by means of a velocity sensor instead of the derivation of the displacement. As the result, acceleration and hence force are more reliable than standard type of LPT. Typically, the LPT is connected to a PC and displays data in real time. Some LPT display data with a special handy monitor which not only shows velocity and power with clear and bright LED so that athletes and coaches can share the information immediately, but also can be used for a real time monitoring of percentage to the maximum values produced during a running set. By keeping the quality of effort at each repetition as high as possible based on the percentage value, athletes can prevent insufficient stimulation of CNS due to fatigue or lack of motivation.

Accelerometer

A light weight (40-60g) portable accelerometer system attached to the shaft of a barbell is another option to measure speed and power in practical resistance training sessions. Common devices contain 3-dimensional inertial accelerometer to directly obtain vertical instant acceleration with sampling frequency of 500 Hz. Velocity is now calculated from integration of acceleration, and displacement is calculated from integration of velocity. Force and power are obtained by same calculation as LPT

Reliability and validity

Most studies [2,3,4,5] have shown that LPT and accelerometers are reliable and valid, therefore the systems can be employed for cross sectional tests, when a coach want to compare the performances of different athletes at the same moment, and for longitudinal monitoring, when the performances of the same athletes have to be compared at the different moment of the training.

CACE STUDIES

In resistance training to be performed to develop athletic performances which are characterized by exertion of explosive power and execution of high velocity movements, to increase 1RM itself is effective at some stage of development of the athletic performance. However, to increase force produced at higher velocity, namely to produce higher power is becoming more important at the later stage of the training.

A case study [6] showed that lifting speed decreased in a resistance training in which the weight to be lifted increased when subjects successfully completed number of repetitions prescribed in a program, unless subjects tried to maintain the lifting velocity or to increase the lifting velocity intentionally. However, when real time feedback on the actual lifting velocity of the each repletion recorded by the LPT monitor was verbally given, lifting velocity was tended to be maintained till the load increased very heavy weight(Fig.1).

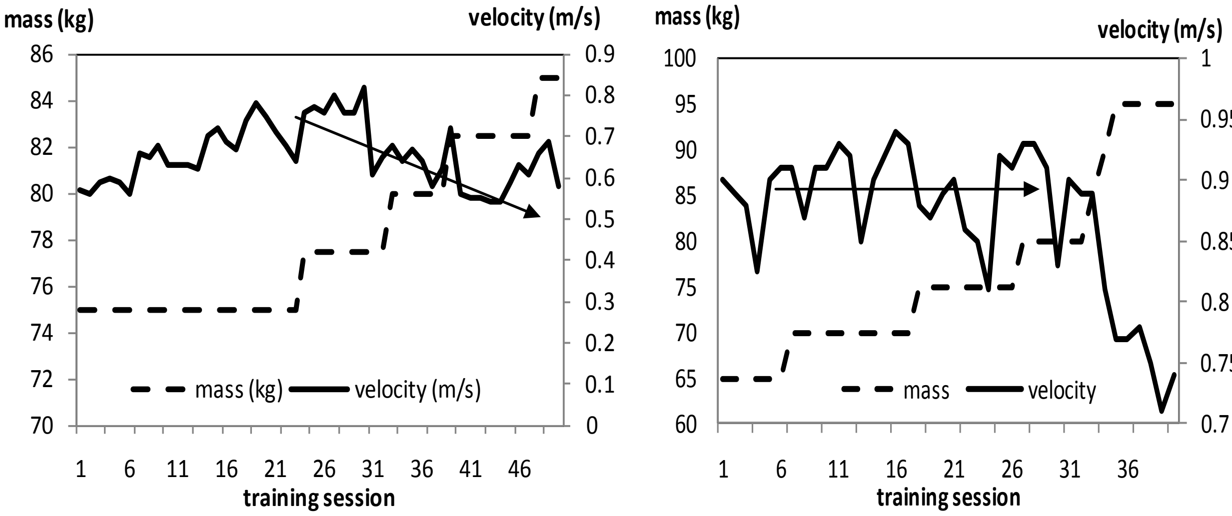

Fig.1 Changes of lifting velocity accompanied by increasing the mass lifted in bench press exercises. The lifting velocity began to decrease when the mass started increased (left). The lifting velocity was maintained even the mass increased, and drastic decreasing velocity was observed at the final stage of the training (left).

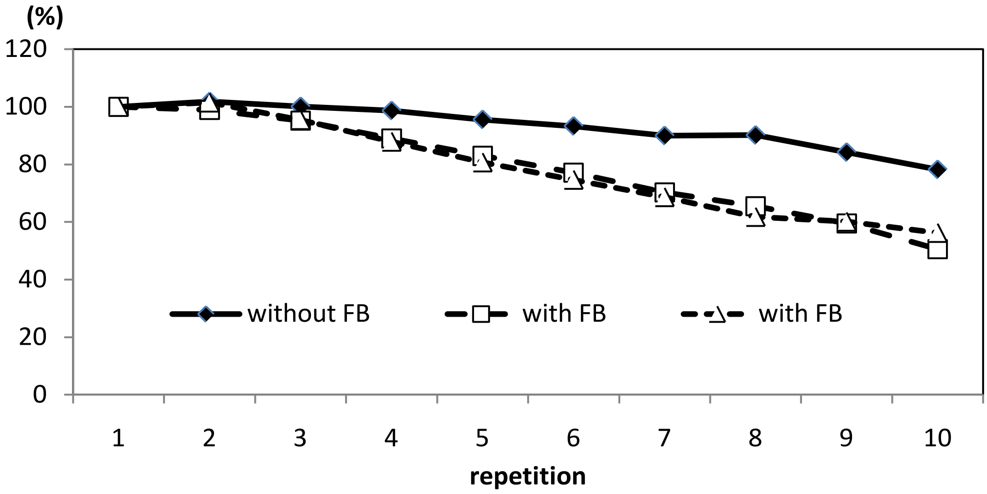

Fig.2 Decreasing of relative velocities at each repetition averaged for the total training period (6 weeks). Two subjects given real time velocity feedback were not able to maintain the velocity (-50%), however subjects without feedback maintain velocity approximately 80% of the first repetition.

Subjects instructed to maintain lifting velocity throughout the all repetitions as high as possible with verbal real time feedback of actual lifting velocity had to recruit higher percentage of type II muscle fibres and ATP-CP energy system, resulting faster fatigue than subject who trained at own pace(Fig.2).

As the result of the 6 weeks training periods, the subject trained in maximal effort with the real time feedback of the lifting velocity increased bench press power from 274.2 watt with the lifting weight of 62.5kg to 502.8 watt with 65.0kg (45.5% improvement). On the contrary, the subject trained in own velocity without any feedback information of the lifting performance increased from 412.0 watt with 75.0kg to 575.4 watt with 85.0kg (28.4% improvement).

AN INTERVENTION STUDY

Previous studies which dedicated to elucidate an optimum training program variable to develop explosive power based on paradigm of heavy vs. light and slow vs. fast failed to control lifting velocity for light and fast training group. As seen in Fig.2, intention to maintain lifting velocity and maximal effort to produce repeatedly high rate of force development decreased actual movement velocity [7]. Purpose of real time feedback of lifting speed is not to maintain actual velocity of the lifting movement and to prevent lowering actual movement velocity, but to stimulate motivation to maintain intended movement velocity to maximize intra and inter coordination of NMUs.

To test this hypothesis, novice collegiate football players were divided to three groups. A speed controlled squat group performed 3sets×10RM, a jump squat group performed 4sets×6 repetitions with 30kg barbell without any feedback on exercise speed, and another jump squat group used same program, but were given real time feedback of movement speed. Although there was no significant difference of movement velocity between with and without feedback group at any repetition and any training session, only the jump squat group with real time feedback improved power output in the jump squat with 30kg after 4 week training period (Fig.3).

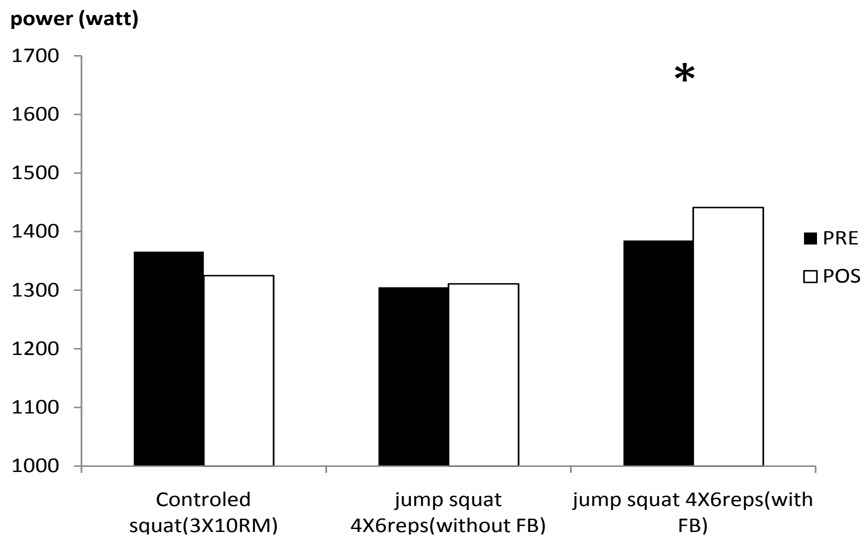

Fig.3 Power output in jump squat with 30kg before and after training (2 times a week for 4 weeks). Only jump squat group with real time feedback of lifting speed improved power (**p*<0.05).

INDIVIDUAL MUSCLE PROFILES

To enhance the efficiency of resistance training to improve power production for specified athletic performance particular load zones should be determined for particular sports and individuals. For this purpose, Individual muscle profiles described according to load-power and load-velocity relationships can be used. From a set of data on the movement speed and mass used in the exercise movement, 1RM values are estimated using interpolation at the point where movement velocity is 0 or very slow such as 0.1m/s. Based on the individual load-power curves varied from athletes to athletes, five major training zones could be discriminated [8]. The five training zone, i.e. maximum velocity, power-velocity, strength-power, hypertrophy and maximal strength are distinguished based on intersection point made by 90% line of maximal power and power curve called power plateau. These training zones determined from actual monitoring individual lifting speed are significantly different from training zone decided by simple percentage of 1RM value. An accelerometer is now available to easily obtain these training zones in a practical training session.

PRACTICAL APPLICATIONS IN ATHLETIC PERFORMANCE ENHENCEMENT

An experienced male shot putter performed snatch exercise 2 times a week from 3 weeks prior to the first competition in a season. After the competition the subject trained another 3 weeks to the next competition. Number of repetition, sets, and load values were determined by subject. Verbal real time feedback of power produced at each repetition was given. Subject was instructed to discontinue the repetition when <80% of maximal power was monitored for 2 times within the set. Although 1RM didn't change before and after training, pronounced increase in power produced at every percentage of 1RM was observed (Fig.4). As the result of the training, seasonal and carrier best record were made after first 3 weeks and another 3weeks, respectively [9].

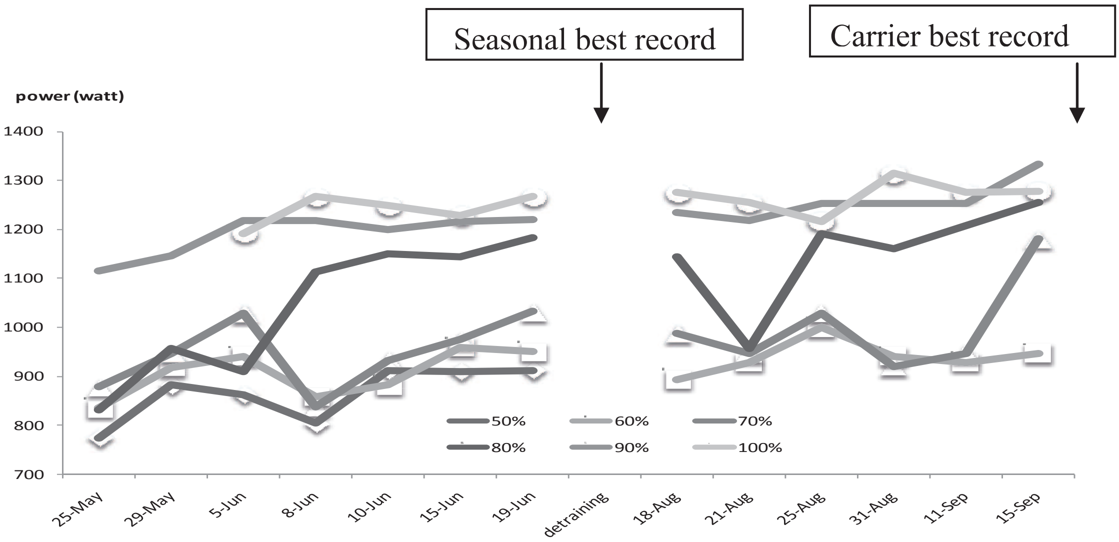

Fig.4 Changes in power produced at 50, 60, 70, 80, 90, and 100% of 1RM snatch exercise. Seasonal and carrier best record were set after first and second 3 weeks training, respectively.

CONCLUSION

Real time feedback of exercise speed and power actually produced in practical training sessions could enhance the efficiency of strength training to improve athletic performance. Coaches can use these information obtained in each training session to monitor and improve the training.

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Friday 11:00-12:20

Strength Training in Clinical Practice

Benefits of Strength Training in Musculoskeletal Diseases

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Although physical activity cannot totally stop the biological aging process, there is evidence that regular exercise can minimize the physiological effects of an otherwise sedentary lifestyle and increase active life expectancy by limiting the development and progression of chronic disease and disabling conditions. Patients with musculoskeletal disorders (MSDs) are also known to be at risk for physical inactivity, similar to patients with other chronic conditions (1). MSDs are the most common work-related health problem in Europe, affecting millions of workers. Across the EU 25% of workers complain of backache and 23% report other types of muscular pain. In some nations of EU 40% of the costs of workers' compensation are caused by MSDs making these diseases expensive also for the society. On the other hand, the risk of all cause mortality can be reduced by 30% in those who participate in regular physical activities compared to those who have an inactive life style.

There is increasing evidence showing the beneficial effects of resistance training for the musculoskeletal system. This knowledge has led to recommendations that strength training should be included in an overall fitness program for all adults (2), and it is especially recommended for older adults. The revised ACSM guidelines recommend at least 2.5 hours of moderate-intensity or 1.25 hours of vigorous-intensity aerobic physical activity per week. The new perspective of the recommendation is to include also moderate- or high-intensity muscle-strengthening activities for all major muscle groups two or more days a week (3,4).

The recommendations are based on research demonstrating that resistance exercise training has profound effects on the musculoskeletal system. It contributes to the maintenance of functional abilities, and prevents osteoporosis, sarcopenia, lower back pain, and other disabilities. In addition, it can be used as a central non-pharmacological treatment for neck and back pain, rheumatoid arthritis, osteoarthritis etc. More recent research demonstrates that resistance training may positively affect risk factors such as insulin resistance, resting metabolic rate, glucose metabolism, blood pressure, body fat, and gastrointestinal transit time, which are associated with diabetes, heart disease, and cancer (5). The focus of this abstract is on chronic MSDs (rheumatoid arthritis, low back pain, chronic neck pain), leaving out traumas, acute tendinitis etc.

Rheumatoid arthritis (RA): Rheumatoid arthritis (RA) is a chronic inflammatory auto-immune disease, causing progressive damage to the musculoskeletal system, as well as other organs in the body. Many patients with RA also suffer from accelerated muscle loss or cachexia, which contributes to the loss of physical function and quality of life. Physical activity plays a central role in the management of the disease as it is essential to maintain muscle strength and endurance, range of motion and the ability to perform activities of daily life. However, quite a small number of studies reporting the effects of different types of training methods on muscle strength in RA have been published (6). In these studies the intensity of the exercise programs have ranged from low to high, and in many studies the training protocol has been described so briefly that the actual loading level remains unclear. Exercises have been carried out by using dynamometers, cycle ergometers, elastic bands, dumbbells, water, or body weight as resistance. Most studies investigated the effects of exercise in patients with a long duration of RA, but also patients with recent-onset RA were included. Muscle strength was measured using isometric, isokinetic, or dynamic testing actions. The specificity of training can be seen from the results. The relative increases in knee extension strength values were highest in those studies including actual high-intensity strength training compared with lower intensity mixed strength and aerobic training programs, or pure aerobic methods. The length of the training period has varied from 3 weeks up to 2 years.

A limited amount of evidence is available about the effect of strength training on muscle mass in RA. One study has reported an enlargement of 5.5% in the cross-sectional area of the quadriceps femoris muscle after 6 months of progressive strength training (7) and another 7.4% ($p < .001$) increases of the quadriceps femoris thickness after the 21-week combined strength and endurance training period (8). All the applied training methods seem to be safe treatments for adults with RA. Most of the studies reported no changes and a few of them even some decreases in disease activity often measured by ESR, joint count, and pain. None of the studies reported increased progression of joint damage in small joints due to training, although the studies had rather long follow-up times (up to 2 years) (6). However, exercise may have detrimental effect on large joints in the subgroup of patients with an extensive pre-existent large joint damage (9). Only one study has reported the effects of strength training on bone mineral density (BMD) concluding that the effect of exercise on BMD in RA may be small, but it may become substantial, if accumulated over years as prolonged physical exercise delays the decrease of age-related bone loss (10).

Low Back pain (LBP) is usually defined as pain, muscle tension or stiffness localized below the costal margin and above the inferior gluteal folds, with or without leg pain (sciatica). LBP is typically classified as being ‘specific’ or ‘nonspecific’. Specific LBP refers to symptoms (such as hernia nucleus pulposus, spinal stenosis, istmic or degenerative listhesis, inflammation, osteoporosis, fracture or tumor) caused by a specific patho-physiological mechanism. Only in about 10% of the patients specific underlying diseases can be identified (11). The vast majority of patients (up to 90%) are labeled as having nonspecific LBP, which is defined as symptoms without a clear specific cause, that is, LBP of unknown origin. A recent Cochrane review (12) included sixty-one randomized controlled trials (including 6390 participants): acute (N=11), subacute (N=6) and chronic (N=43) low-back pain. In acute low-back pain, there is evidence that physical exercises are not more effective than other conservative treatments. There is some evidence of effectiveness of graded-activity exercise program in subacute low-back pain in occupational settings. In chronic low-back pain, there is strong evidence that exercise is at least as effective as other conservative treatments. In this review these studies have been too heterogeneous to be stratified into ’flexion and/or extension exercises’, ’strength exercises’ or in ’back specific exercises’ (and they are further sub-divided into many forms; McKenzie; transversus abdominus and multifidus retraining etc.). Individually designed strengthening or stabilizing programs appear to be effective. However, there is no evidence that any type of exercise is clearly more effective than others in non-specific LBP. On the other hand, magnetic resonance imaging, computerized tomography and ultrasound imaging studies have shown atrophy of multifidus muscles after prolonged bed rest in low back pain patients (13) or after lumbar fusion (14). Also long incisions require extensive deflection of the muscles, and subsequent prolonged wide retraction causing ischemic changes may result in denervation of paraspinal musculature (14). Patients after lumbar disc herniation surgery have significantly lowered maximal strength and explosive force capacity of the trunk muscles compared to healthy controls (15). In addition, there is an imbalance between trunk extension and flexion strength levels. Based on these finding there is a deficit in muscle function in LBP patients, but more studies are needed to specify the best muscle training protocols.

Chronic neck pain: Neck pain can result from disorders of any of the structures in the neck, including the cervical vertebrae and intervertebral discs, nerves, muscles, blood vessels, esophagus, larynx, trachea, lymphatic organs or thyroid glands. It is generally accepted that muscles play an important role in the support and protection of joints. Ligaments and the neck extensor muscles also support the head in an up-right position against the forces of gravity. Neck muscles have direct attachments to the vertebrae and are responsible for the segmental stability of the cervical spine through the control of the neutral zone. According to a recent Cochrane review (16) isometric, isokinetic or isotonic strengthening exercises are used in training for neck pain. The interventions have utilized machines, rubber bands, weight of the head, free weights, or low load endurance exercises to train muscles. Although according to the review there is limited evidence of benefit for strengthening, exercises for neck disorders, some high quality studies have shown good results in increasing neck muscle function. Ylinen et al (2003) studied effect of 12 months of training in 180 females (ages of 25 and 53 years) with chronic, nonspecific neck pain (17). The endurance training group performed dynamic neck exercises, which included lifting the head up from the supine and prone positions. The strength training group performed high-intensity isometric neck strengthening and stabilizing exercises with an elastic band 3 times a week. The control group had stretching instructions only. Maximal isometric neck strength improved in flexion by 110%, rotation by 76%, and extension by 69% in the strength training group. The respective improvements in the endurance training group were 28%, 29%, and 16%, and in the control group 10%, 10%, and 7%. At the 12-month follow-up visit, both neck pain and disability had decreased significantly in both training groups compared with the control group (P<.001).

As the structures of the neck are vulnerable for overloading, it is important to check out the possible risks of training. For example, rheumatoid arthritis patients with atlantoaxial subluxation have the laxity of ligamentum transversus, which support dens of axis against atlas. In these cases isometric exercising towards flexion decreases the atlantoaxial distance and are safe. However, submaximal loading of the neck extensors by pushing the back of the head against the resistance even in the neutral position of the cervical spine leads to a decrease in the width of the cervical spine canal and is not recommended in unstable aAAS.

Conclusions: Based on the present findings, strength training can be recommended in musculoskeletal rehabilitation. Furthermore, to be effective it is important to individualize the protocols, control and adjust the loads, and try to induce sufficient levels of neuromuscular activation to stimulate training-induced muscle hypertrophy and gains in muscular strength.

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ELECTRICAL INDUCED FORCE TRAINING IN HUMANS WITH COMPLETE LOWER MOTOR NEURON LESION

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INTRODUCTION

The effects of complete spinal cord injury (SCI) are the immediate loss of voluntary movement, activity and contractile force, closely followed by a significant decrease in muscle mass and stimulation-evoked force. Atrophy of skeletal muscle groups is particularly severe when SCI involves all the lower motor neurons (LMNs). After such a complete nerve injury, the peripheral endings of motor neurons quickly degenerate and the denervated muscles undergo progressive decay, which can be phased as follows: (*a*) within days denervated muscle starts to develop spontaneous activity in sparse muscle fibers (action potentials, fibrillations); (*b*) after weeks, the muscles activated by electrical stimulation are not able to sustain tension during tetanic contractions; (*c*) within months, muscles are undergoing severe disorganization of contractile apparatus and are not longer excitable with standard commercial electrical stimulators; and (*d*) after years, the myofibers are replaced by adipocytes and even more collagen.

To counteract the progressive changes that transform muscle into an unexcitable tissue, we have developed a novel training concept for paraplegic patients with complete lesions of the conus and cauda equina (CC) over the past 20 years. This new training strategy became possible because of the development of a new generation of stimulation equipment specifically designed for functional electrical stimulation (FES) for tetanic training of atrophied and/or degenerated muscles.[1-6]

METHODS

All 25 subjects (aged 20-55 years; 5 females and 20 males) suffering from a CC lesion (up to 9.0 years of complete and permanent peripheral denervation) were volunteers who received detailed information and signed an informed consent. Complete denervation of right and left quadriceps muscles was assessed before and after 2 years of FES by test electrical stimulation, needle electromyography, and both transcranial and lumbosacral magnetic stimulation.

Patients were provided with stimulators and electrodes (conductive polyurethane 180cm2 inside wet sponge cloth) to perform training sessions by FES at home for 5 days every week. As soon as the skin was accustomed to the necessary high current density, gel was used under the polyurethane electrodes to achieve minimal transition impedance.

At the beginning of the treatment, biphasic stimulation impulses of very long duration (120-150 ms) at high intensity (up to ± 80 V and up to ± 250 mA) were applied and clinically evaluated every 4 weeks by physiatrists. After the first period (3 to 6 months) of twitch-contraction training, the routine daily training consisted of combined twitch and tetanic stimulation patterns against progressively increased loads in consecutive sessions lasting up to 30 minutes for each group of muscles (gluteus, thigh, and lower leg muscles on both sides) a day.

Muscle cross-sectional area (CSA) was documented by quantitative analysis of computer tomographic images from the patients' thighs before and after 2 years of FES training. Changes in tissue composition within the muscle were visualized by associating Hounsfield Unit (HU) values with different colors (red = normal muscle, orange = atrophic muscle, blue = connective tissue, yellow = intramuscular fat).

Isometric knee extension torque (TOR) was measured by electrically stimulating the quadriceps muscles of patients seated on a custom-designed chair with the knees flexed 90° degrees.
Muscle biopsies obtained in vastus lateralis muscles were analyzed for fiber diameter (MFD), types (hematoxylin–eosin or ATPase at pH 4.35) and electron microscopy analysis before and after 2 years of FES.

RESULTS

The analysis of quadriceps muscle CT scans (Fig.1A+B) indicates that the interstitial tissue increases with greater denervation time in samples collected before FES training (note the increasing fibrotic tissue, colored blue, Fig. 1C). On the other hand, the CSA of thigh muscles from the same patients after the 2 years of FES (and, therefore, of permanent denervation – Fig. 1B+D) are visibly larger, whereas the fibrotic muscle tissue colored in blue is reduced (Fig. 1D). The increase in muscle size and density involves also the hamstrings, even though the surface electrodes were located on the front part of the thigh. The measured increase of the cross-sectional area from 28.2 ± 8.1 to 38.1 ± 12.7 cm2 (+ 35 %, $p < .001$, Fig. 2), support the visual observations.

Before FES, the whole group of patients had an average maximum knee torque (TOR, Fig. 2) of 0.8 ± 1.3 Nm, whereas after the 2 years of FES training the average maximum torque increased to 10.3 ± 8.1 Nm (+ 1187 %, $p < .001$). No patient reaches more than 5 Nm before starting FES training. After 2 years of FES values up to 30 Nm are possible, much lower than in healthy humans.
There is a limit in measurable torque because of electrical induced co contractions of the hamstrings muscles and the missing recruitment order.

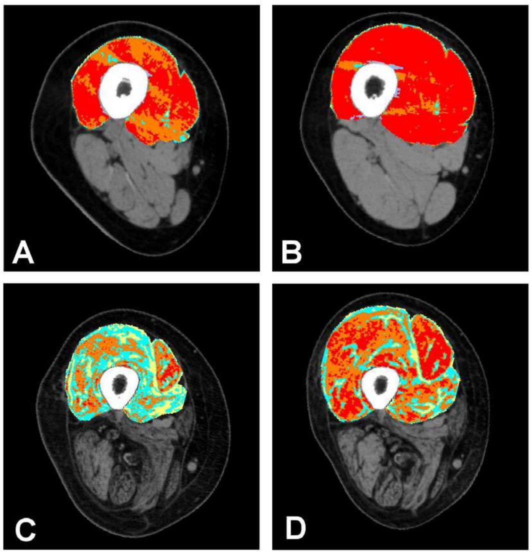

Fig.1 Color CT scan of thigh muscle measured in patients at different times after denervation (A=0.8; C=5.4 years), before (A,C) and after 2 years of FES (B,D). Color code: red = normal muscle, orange = atrophic muscle, blue = connective tissue, yellow = intramuscular fat.

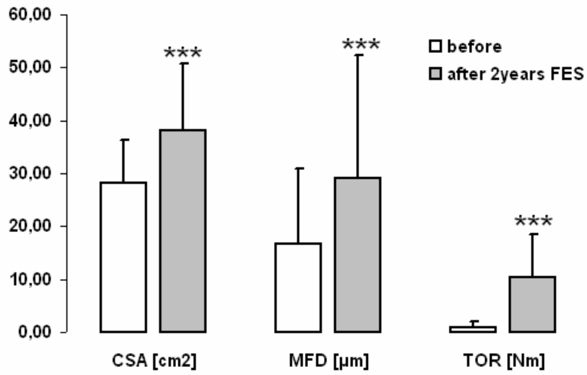

Fig.2 Cross-sectional Area, mean muscle fiber diameter and isometric torque measured before and after 2 years of FES training.
before vs. after: *** $p < 0.001$

In the case of permanent LMN denervation, muscle continues to lose mass during the first year (and beyond) (Fig. 3A+C) and progresses to severe atrophy and degeneration with muscle fibers substituted by adipose and fibrous tissues. During the first year of LMN denervation, the denervated fibers maintain the differential fast and slow characteristics, whereas later on only sparse fast-type muscle fibers are detected.

We have measured the average increase in size of muscle fibers: the difference in mean myofiber diameters (MFD, Fig. 2) measured before and after 2 years of FES training, showed a highly significant ($P < .001$) 75% increase from 16.6 ± 14.3 (n = 48) to 29.1 ± 23.3 (n = 35) mm

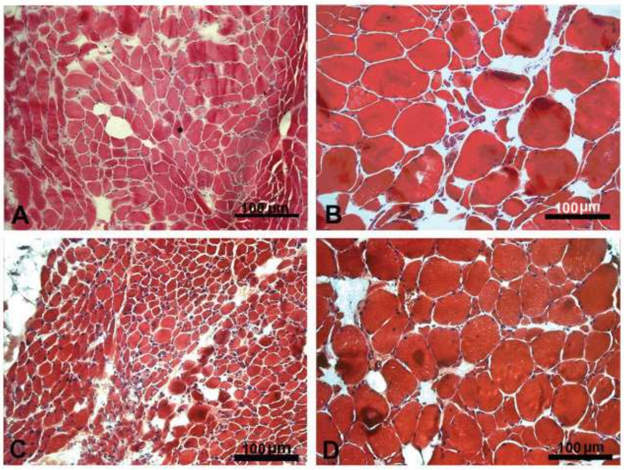

Fig.3 Light microscopy of muscle biopsies from LMN paraplegic patients before (A, C) and after (B, D) 2 years of FES training.

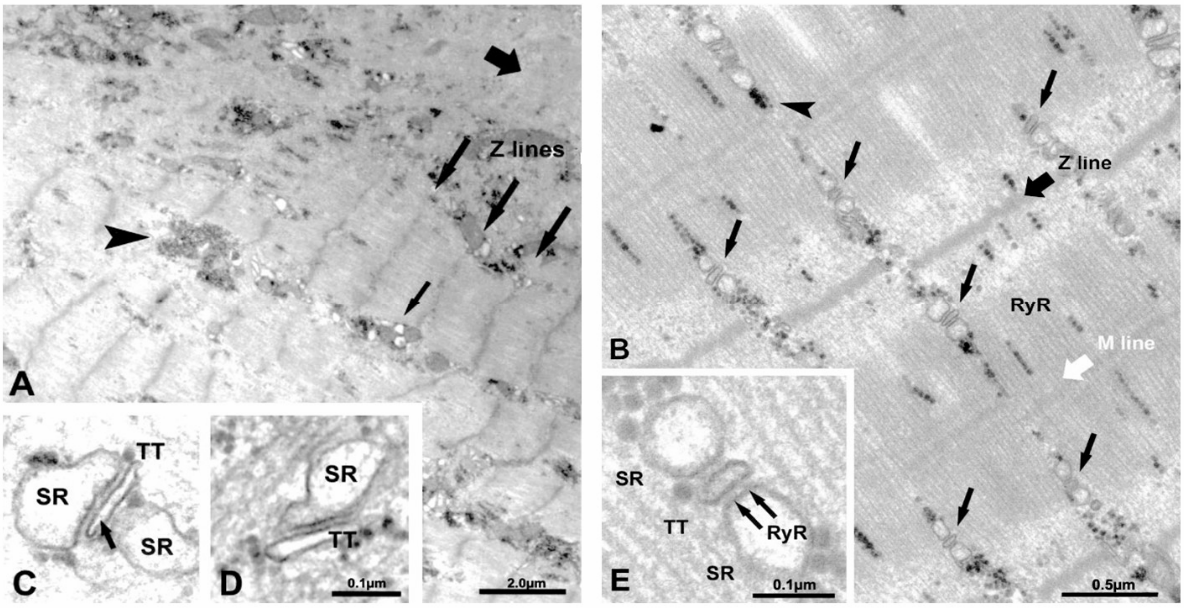

Fig.4 FES-induced ultrastructural restoration of fiber structure. Muscle of patient show degeneration of the contractile apparatus before (A) and recovery after 2.4 years of FES (B), especially reorganizing Triads, SR and regular cross striation of muscle fiber in human.

In EM analyses of longitudinal sections, human LMN denervated muscles show features of denervation atrophy, whose severity depends on the time elapsed from the injury. Classical alterations of the contractile apparatus are evident in the analyzed muscle biopsies; myofibrils are often interrupted and/or completely missing in several areas, and sarcomeres are often altered with misaligned Z lines and missing M lines (Fig. 4A). The sarcoplasmic reticulum (SR) is often dilated, misshaped, and sometime vesicled: triads or dyads, formed by the association of SR with transverse tubule (T-tubule) profiles are present, but they are usually abnormal in appearance or missing (Fig. 4C+D). Mitochondria decrease in number, often they lose their specific positioning at the I band of the sarcomere and are often grouped in an abnormal fashion.

Muscle fibers from biopsies collected after the 2 years of FES (Fig. 4B) present structural improvements with respect to biopsies collected from the same patients before the training. A well-defined pale dark cross-striation, which characterizes skeletal normal adult muscle fibers, occupies the majority of the fiber interior (Fig. 4B) on the whole fiber. However, we must report that myofibril restoration is not yet complete and uniform throughout the cross section, possibly because of the limited daily time of FES treatment or the total training time of 2 years. In fact, reorganized regions may coexist with areas in which myofibrils are not completely reassembled yet. After 5 years of stimulation our preliminary analysis show that the whole muscle and all fibers seems to be reorganized.

In parallel to the restoration of myofibrils with reorganization of the cross-striation, the membrane systems involved in the excitation contraction (EC) coupling mechanism (triads, or Ca2+ release units, which are reputed to release Ca2+ in response to the action potential) also become more numerous (Figure 4E). The formation of mature triads seems to closely follow the reorganization of the myofibrils; triads are, in fact, more frequent and better oriented in those regions presenting with well-differentiated myofibrils than in those areas in which myofibrils are still incomplete and/or missing.

DISCUSSION

Our data show that FES training is effective to counteract muscle atrophy and degeneration after complete LMN denervation due to CC lesions. The FES device stimulates muscle fibers in the absence of nerve endings and after prolonged denervation, enabling recovery of muscle mass, fiber size (Fig. 1-3), tetanic contractility (Fig. 2), and restoration of muscle fiber ultrastructure (Fig.4).

Our light microscopy results (Fig. 3) suggest a window for intervention in patients up to 2 years after injury, because fibers maintain at least 30% of their initial size and the extracellular matrix is still evolving. EM analyses (Fig. 4) indicate that the structure of the sarcotubular system and myofibrils decays quite quickly, suggesting that it is best to start FES training as soon as possible after SCI.

At 2 years, 90% (n = 20) of FES trained subjects recovered or increased tetanic contractions, and some patients stood during electrical stimulation in parallel bars. Minimal functional improvements were associated with long time elapses between SCI and initiation of FES training and possibly lower compliance with training.

CONCLUSION

In conclusion, our findings support our new rehabilitation protocol as a method to improve the mass and contractility of LMN denervated muscles, although we found limited “measurable” knee torque changes in FES trained muscles. These benefits could be extended to patients with similar lesions, especially to reduce secondary complications related to disuse and impaired blood perfusion (reduction in bone density, risk of bone fracture, decubitus ulcers, and pulmonary thromboembolism).

The effectiveness of muscle adaptation and functional improvement at all depends on continuous daily activity and life long training. In our new EU-project “MOBIL” we transfer our knowledge from handicapped to elderly humans.

FUNDING

Supported from the EU Commission Project RISE (Contract no. QLG5-CT-2001-02191), the Austrian Ministry of Science and the Ludwig Boltzmann Society.

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Saturday 8:30-10:30

Mechanisms of Muscle Adaptation to Resistance Training I.

Molecular and Cellular Mechanisms involved when skeletal Muscle is subjected to active stretch.

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Skeletal muscle repair, mass and strength adaptation.

Muscle is a mechanical tissue and in most individuals this tissue has the ability to increase power output by undergoing hypertrophy. However, the ability to maintain muscle mass and strength diminishes with age even in individuals who exercise regularly. Our group have studied muscle adaptation, wasting at the gene level based on the realisation that there must be local as well as systemic regulators of muscle growth. We cloned a mRNA of a factor that was apparently important in local regulation of muscle mass by using an animal model in which we could make muscle grow rapidly. Also we showed that when the tibialis anterior in the mature rabbit was electrically stimulated using an implanted microcircuit whilst held in the stretched position by a plaster cast, it increased in mass by 35% in just over 7 days [1]. It was previously shown that muscles adapt to an increased functional length by adding sarcomeres in series at the ends of the existing myofibrils but when subjected to electrical stimulation they also increased in girth by adding sarcomeres in parallel as well as in series. RNA was extracted from these muscles and using differential display we detected a RNA transcript that is expressed in stretched/exercised but not in resting muscle. After this mRNA was converted to cDNA, sequenced and referred to the genome data base and it was found to be derived from the insulin-like growth factor (IGF-I) gene although its 3' sequence is different to the liver or systemic type of IGF-I but similar to the rodent IGF-IEb [2]. Later work showed that in human muscle there are 3 main types of IGF-I but the terminology based on rodents was confusing. Therefore, we called this newly discovered splice variant, mechano growth factor (MGF) as it is only expressed in response to mechanical strain. It was apparent that MGF although derived from the same gene, as the liver type IGF but it had to be characterized separately. MGF expression is mechano sensitive and during splicing from the IGF-I gene a reading frame shift is introduced which results in a unique 3' sequence that encodes a different carboxy peptide which has several unique actions. This MGF C terminal peptide may become detached from the main body of the molecule but importantly this small peptide has been found to activate the muscle satellite (stem) cells and also to restrict damage in skeletal muscle and in other tissues. Strength training is believed to involve micro-damage in the over strained muscle fibres and it is likely that this is an adaptation to muscle damage and muscle repair and some micro damage may be a pre-requisite for hypertrophy.

MGF positive regulator of muscle adaptation and repair.

Skeletal muscle is called a post-mitotic tissue because no further mitotic divisions within the myofibres after embryological development in the muscle fibres. However, there are residual myoblasts that were called satellite cells because their position as they are found between the plasma membrane and the basal lamina of the myofibres. When activated these satellite cells, which are muscle progenitor (stem) cells, fuse with the muscle fibre to provide the extra nuclei required for hypertrophy and repair throughout life. One of the most important functions of this unique MGF C-terminal peptide is to replenish this muscle progenitor (stem) cell pool by inducing them to multiply but to stay as mono nucleated stem cells [3,4,5]. This is apparently a two stage process as the unique MGF peptide activates replenishment and the fusion of these cells with the muscle fibres and mature IGF-I is the stimulus that induces them to enter the myogenic pathway and produce additional muscle proteins [4,5]. Using human muscle stem cells derived from patients with muscular dystrophy or ALS as well as normal muscle, it was encouraging to find that the muscle stem cell pool can be replenished by using the MGF peptide [5]. Recent work with Gillian Butler-Browne's lab in Paris has shown that muscle satellite cells taken from a neonate a adolescent male and an elderly man can be activated by the unique MGF C terminal peptide and that it has considerable potential as a therapeutic agent particularly in the elderly who do not respond to weight training and who do not produce the positive activator MGF although the negative regular, myostatin is reduced in some elderly weight lifters when they retrain (Tschen, Wessner and Bachl data to be presented at this conference). As far as the positive regulators are concerned, in vivo animal studies have shown that following muscle damage the expression kinetics of MGF and the other types of IGF-I differ [6]. MGF is produced shortly after the start of exercise but IGF-IEa production does not peak until well after the replication of the muscle stem cells has ceased. MGF which appears after just one bout of resistance exercise [7] which has a short half-life and is really just produced as a pulse lasting a day or two. Bamman's group [8] found that after resistance exercise there was a correlation between cyclin D1 activity with MGF expression demonstrating the burst of cell replication. Therefore, MGF rather than IGF-I is a candidate for treating muscle loss and repair as this involves replenishing the muscle satellite (stem) cell pool which "kick start" the growth and repair processes. Unfortunately the ability to produce MGF is age-related. Older muscles are less able to produce MGF and this seems to be associated with the marked decline in growth hormone and testosterone which are known to initiate and control the expression of the IGF-I gene. The decline in growth hormone and the IGF-I primary transcript means that less can be spliced to produce MGF. However when elderly men were given hGH and exercised, muscle cross-sectional area as well as MGF levels were increased [9]. Also as we get older the muscle connective tissue becomes stiffer and the mechano transduction systems that include Focal Adhesion Kinases that are upstream of MGF become more difficult to activate but are improved by regular exercise.

Other functions of MGF.

Exercise is regarded as beneficial to health but not all aspects have been appreciated. MGF has been found to be expressed in several other musculoskeletal tissues when subjected to mechanical strain tissues including tendons and bone and vascularisation of damaged tissue. Also early work using an animal model system to asses neuro-protection in which the facial nerve of the rat is damaged and the survival of the motorneuron cell bodies counted showed that full MGF was twice as neuroprotective as IGF-I. The Dluziewska study [10] also involved the Gerbil model of stroke in which one side of the brain is subjected to ischemia. This evoked expression of endogenous MGF suggesting that this may be an important natural neuroprotection mechanism. When the C terminal peptide of MGF was introduced into the blood supply on that side of the brain, there was marked protection of the neurons. Also experiments were carried out using the rat brain slice technique. Hippocampal slices were prepared from young rats and maintained in the special chambers in special culture medium for two weeks and checked daily. MGF C terminal peptide produced up to 85% protection whereas IGF-I which is known to protect against ROS was much less effective and only noticeable up to 24 hours. This solves the enigma – that is to say exercise involves more oxygen uptake and as the free oxygen radicals are taken on board it is expected that more free radical tissue damage will occur. However it has been found that MGF protects against damage of tissues by ROS [10] and therefore exercise is beneficial from this point of view and other aspects of tissue maintenance.

Use and misuse of MGF.

Blogs from body builders testify that the small MGF peptide is very effective in building muscle but even the synthesised small peptide is expensive. However, groups in different countries including China and Russia are producing MGF by recombinant methods similar to those used for human insulin and hence this means it will be or is now, very inexpensive. The uses of MGF for treating diseases such as muscular dystrophy, ALS as well as age related muscle loss are laudable but unfortunately it will also be used to enhance athletic performance. However, funded by WADA, the author and colleagues have developed a test for detecting its misuse.

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Does the eccentric exercise down-regulate myostatin and induce muscle fiber proliferation?

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Prerequisites for muscle hypertrophy

Since Wilhelm Roux (1850 - 1924) it is accepted that muscular hypertrophy occurs only when muscles are forced to work intensively. This theory was demonstrated first experimentally by Werner W. Siebert. However, the mechanism behind this phenomenon remained unknown for a relatively long time. It was expected that regular resistance exercise elicits acute and chronic physiological alterations resulting in growth of the muscle fibers. Also, it became clear that anabolic hormone administration causes muscle fiber hypertrophy, but the question how the resistance training influence hormonal system was only answered during the last thirty years due to the excellent studies of Kreamer and Hakkinen.

Several studies demonstrated, that total and free testosterone (TH) level in the serum increased acutely after resistance exercise/strength training, but the resting level remains almost unchanged suggesting that the acute increase of testosterone has a greater influence on muscle fiber hypertrophy than the high resting testosterone level itself. The response of total testosterone to strength exercise influenced by several factors such as muscle mass involved nutritional intake, intensity and volume of the training and types of muscle contraction. It has been suggested that strength exercise that involves large muscle mass is a metabolic stressor that may stimulate the testosterone release.

Growth hormone also increases significantly after resistance exercise. The magnitude of the elevation depends upon several factors such as type of exercise and contraction (i.e. concentric or eccentric), number of muscles involved in the muscle work, training intensity and volume and duration of rest between sets. It seems that resistance exercise with concentric contraction induce greater GH elevation than with eccentric contraction.

Insulin-like growth factor (IGF-1) and its isoforms is also an actor in regulation of muscle fiber proliferation and muscle growth via inhibition of growth regulatory gene myostatin. It has been believed that IGF-1 is produced only in the liver. Now it is clear that other tissues including muscles produce IGF-1 locally. It is recently shown that strength training induces mechano-growth factor (MGF) a splice variant of IGF-1. It seems that IGF-1 and its isoforms play a significant role in reaper of muscle fibers after micro damage by stimulating satellite cells and by increasing protein synthesis. Also, it is demonstrated that anabolic hormones including IGF-1 contribute to the inhibition of myostatin the main regulatory gene for muscle growth in a complicated mechanism via the inhibition of myostatin.

Experiment

Numerous studies were carried out on eccentric exercise induced muscle damage which ranged from mild to severe structural, biochemical alterations in treated muscles. It is widely accepted view that the unaccustomed eccentric training induced micro alterations in myofibrils is a trigger for remodelling. One can assume that for muscle reaper following strenuous resistance exercise should occur with the alteration of anabolic hormone and muscle regulatory gene expression. Recently Liu et al (2003) and Kawada et al. (2006) demonstrated that GH treatment and testosterone administration down-regulated myostatin expression, respectively. This findings suggest that myostatin represents a potential key target for GH-and testosterone-induced anabolism.

Evidence indicates that repeated-bouts of eccentric exercise (EE) do not exacerbate the extent of muscle damage indices, as compared to a single-bout. In our previous studies we hypothesized that molecular adaptations, under repeated bouts of EE, would include suppression of muscle repair inhibitory factors such as myostatin and up-regulation of muscle repair positive regulatory factors such as myogenic regulatory factors (MRFs). Fifteen males were recruited for this study. The exercise group (n = 9) successfully completed six sets of 15 reps of maximum voluntary eccentric contractions, for six consecutive days, using a dynamometer (Multicont-II). Blood and muscle biopsy samples were obtained from each subject 1 week prior to exercise, 2 days post the first training session, and 24 h after the last training session. Gene expression levels were determined using real-time RT-PCR. Blood samples were analyzed for creatine kinase (CK) and lactate-dehydrogenase (LDH) and IGF-1 activity. Repeated-bouts of EE induced a large down-regulation of myostatin mRNA (˜73%) which persisted throughout the study. The responses of MRFs were mild. At day 3 only myogenin increased significantly (1.9 fold) while MyoD decreased by 45%. Surprisingly, at day 7, despite the presence of muscle damage indices, all MRFs returned to the pre-exercise levels. The results of the present study showed that repeated-bouts of EE, for six consecutive days, dramatically decreased Myostatin mRNA expression but impaired the expression patterns of MRFs such that, with the exception of myogenin that showed a moderate non-sustained increase, MyoD and MYf5 response was minimal. IGF-1 increased after the first bout of exercise, but decreased at the 3rd day and retained for the base level at 7th day. No significant relationship was found between gene variables and muscle fiber distribution.

Resistance Exercise Modes and Cellular Signalling Pathways in Skeletal Muscle

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Skeletal muscle is a highly malleable tissue which is able to adapt to environmental and physiological challenges such as acute or chronic exercise but also to ageing and clinical situations such as such as critical illness, inflammatory diseases, cancer cachexia, or prolonged immobilisation [1]. With the increased use of molecular biological methods to study these processes it became obvious that muscle plasticity is regulated by a complex network of intracellular signalling cascades. Common to all these changes is that a perturbation of the cellular homeostasis due to a mechanical, biochemical, hormonal or neuronal signal from outside the cell leads to molecular and cellular responses and finally to functional or structural adaptations [2]. It has been shown that many features of the training adaptations are specific to the type of stimulus. Whereas endurance exercise induces mitochondrial biogenesis, fast-to-slow fibre-type transformation and changes in substrate utilisation, resistance exercise stimulates protein synthesis responsible for muscle hypertrophy [3]. As the adaptations evoked by a resistance training programme differ by the choice of acute training variables such as type of exercise, training load and volume, rest periods between sets and exercises, order of exercises, repetition velocity and training frequency it seems clear that also cellular signalling cascades have to differ [4, 5]. However, we are just at the beginning to unravel the complex networks of muscle plasticity networks. Additionally, men and women exhibit wide ranges of response to resistance training, with some subjects showing little to no gain, and others showing profound changes dependent on gender and age [6, 7]. Individual responses are also determined by our specific genetic make-up. Therefore, the last part of the presentation deals with the genetic determinants of muscle growth.

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Saturday 13:45-15:05

Mechanisms of Muscle Adaptation to Resistance Training II.

Recovery of muscle function and cellular homeostasis after different strength exercise protocols

Truls Raastad, Norwegian School of Sport Sciences

During a bout of strength training neuromuscular fatigue develops gradually. The cause of fatigue can be of both peripheral (muscular) and central (neural) origin, but in most cases the muscular component is most prominent and the longest lasting cause of fatigue. In this paper the focus is on the cellular stress put on muscle fibers during strength exercise, how cellular homeostasis recovers after exercise and how the cellular stress gradually is translated in to adaptation processes when the stress is repeated on a regular basis.

Several components in a strength training protocol influence the development of fatigue during exercise and thereby also the time for recovery after exercise. Some of the most important factors are the contraction form (eccentric – concentric), the load (light – heavy), training volume (low – high) and the intensity (low – high). In addition to the actual training program, the athletes training status is of major importance for how well a certain program is tolerated. In a series of studies we have measured fatigue and recovery after normal strength training regimes (figure 1, upper panel) and after more extreme regimes (figure 1, lower panel). With the more normal regimes executed by well trained athletes, strength of the exercised muscle groups normally decreases by 5-30% and recovers within 50 hours after exercise [1;7-9]. More extreme regimes like sets with forced reps or maximal eccentric muscle actions, results in more pronounced fatigue (40-70% reduction in strength) and long lasting recovery (4 days – 4 weeks) [1;10]. Surprisingly, also exercise regimes with low loads can result in substantial fatigue and long lasting recovery when sets are performed till fatigue (figure 1 lower panel, 30% of 1 RM curve). Fatigue is even more pronounced if low load exercise is combined with blood flow restriction (occlusion) (figure 1, 30% Occl. curve). It should however be noticed that both curves with the low load in figure 1 (30% of 1 RM) is a result of subjects performing this kind of exercise for the first time.

On the cellular level several systems are affected during exercise and therefore the cause of fatigue is multi factorial. Metabolic disturbances are normally recovering fast and therefore mainly contributing to the fatigue experienced during a strength training session. More long lasting disturbances contributing to the fatigue experienced between training sessions are deficits in the excitation-contraction coupling and disturbances in muscle structure like sarcomere disorganization [3;4]. In some cases parts of muscle fibers undergo necrosis, and full recovery of necrotic parts of muscle fibers takes several weeks [5]. This is, however, not a normal response to strength exercise.

The stress on put on muscle fibers during exercise can be evaluated by different techniques. One promising technique is to look at the heat shock protein response after exercise [2;6]. Especially the small heat shock proteins Hsp27 and α-B-crystallin responds fast and in a dose-response manner to the actual stress put on muscle fibers during exercise. One interesting finding in our studies is that with the traditional heavy load strength exercise regimes, type II fibers seem to be the once most stressed, but in the low load blood flow restricted exercise, type I fibers seem to be the once most stressed. Another technique valuable is evaluation of inflammatory processes which can be followed either by scintigraphic techniques (radio labeled leukocytes) or by staining on biopsies.

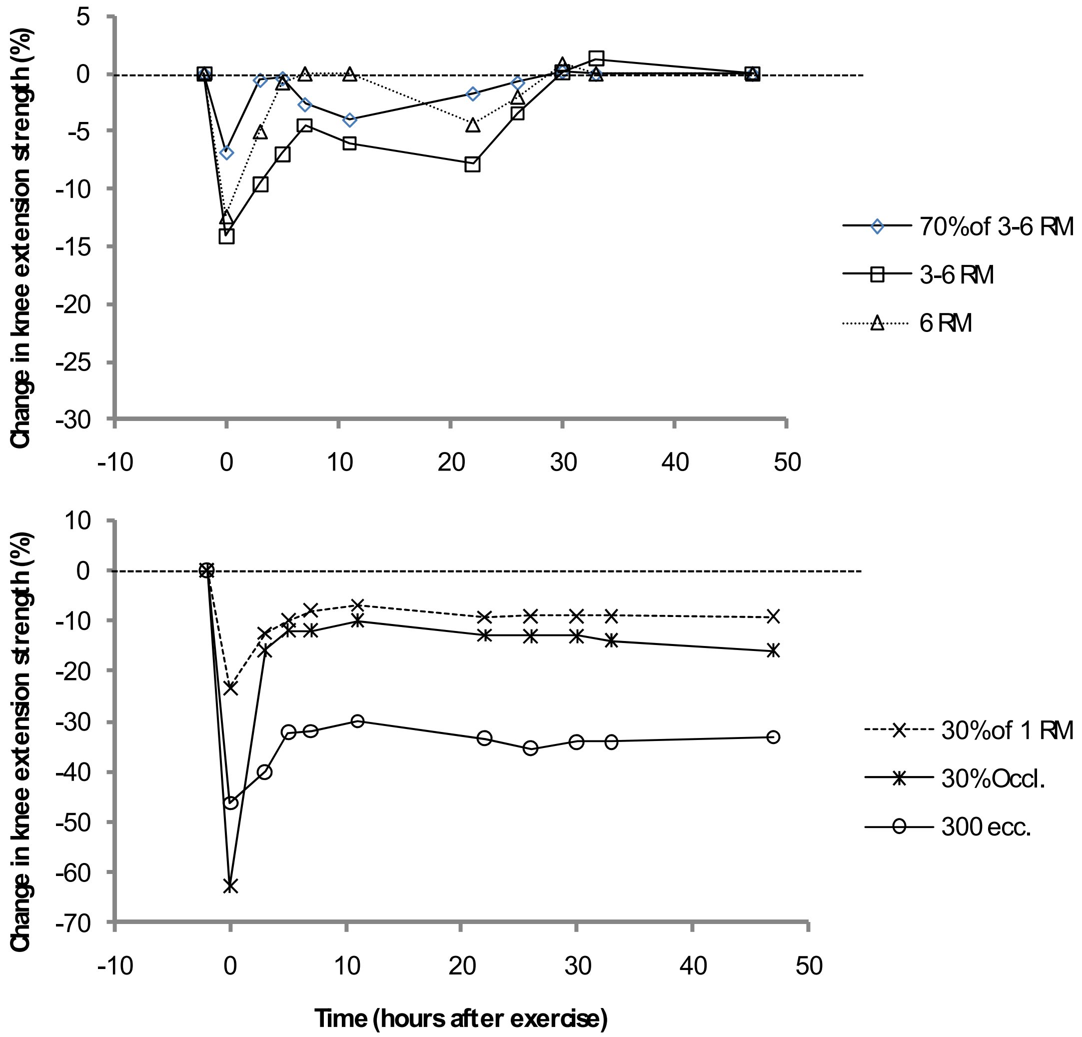

Figure 1. Upper panel: Three normal strength training bouts which all results in recovery of knee extensor strength within 40 hours after the exercise bout. Lower panel: Three more extreme exercise regimes in which knee extensor strength has not recovered 50 hours after the exercise bouts. "3-6 RM" denotes training with loads resulting in fatigue after 3-6 repetitions in a continuous series, in this case 3 RM sets in squat and front squat and 6 RM sets in knee-extension. "6 RM" denotes 6 RM sets performed in squat and knee-extension. "30% Occl." denotes exercise performed to fatigue in 5 sets with a load corresponding to 30% of 1 RM and blood flow restriction accomplished with a tourniquet system on the proximal part of the thigh. "30% of 1 RM" denotes the same exercise performed without vascular occlusion.

By using these techniques it is possible to evaluate the cellular stress put on muscle fibers after various strength training protocols and it is also possible to evaluate the hypertrophic signal produced by the stress in order to get the preferred training adaptation. The goal for most athletes is therefore to combine a certain stress put on muscles in each training session with an optimal training frequency in order to get the best match between training stress, recovery and adaptation. The knowledge about the cellular stress response can therefore be used in the construction of different training regimes and in order to manipulate the recovery after training bouts. Recovery strategies used to speed up recovery has been administration of anti inflammatory drugs (NSAIDS), antioxidants and cooling of the exercised muscles. Although some of these regimes have been shown to speed of recovery between exercise bouts, it is important to highlight the fact that manipulating with these important factors in the recovery processes may actually hamper the adaptation process to training. The last part of the paper will therefore be used to critically evaluate different recovery strategies and how these strategies can affect both the speed of recovery and the adaptation process. Finally, a more practical example will show how the adaptation processes is affected if you dived the training volume in long lasting, high volume training sessions to several shorter, low volume sessions.

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Redox regulation of contracting skeletal muscle

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It is well known that physical exercise can significantly increase the generation of reactive oxygen species (ROS), which readily modulates signaling processes. It has been shown that contracting skeletal muscle generates increased level of ROS, which enhances force generation and in the other hand, it is also known that fatigue of the skeletal muscle could be due to increased level of ROS. Therefore, the delicate balance of generation and elimination of ROS is extremely important in contracting skeletal muscle. Indeed, it turned out that antioxidant supplementations could either delay the fatigue or prevent the oxidative stress related adaptation and impair muscle function. Better understanding of redox processes in the cell would help to develop more sophisticated strength training methods especially for aged individuals, top athletes or those who are using exercise program for diseases recovery.

Saturday 15:30-17:30

A Sport Specific Approach to Strength Training

Specific Strength Training – or how to transfer Improvements of Strength Training into functional Movements

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The findings and knowledge from the last four decades provide a basis for the organization of efficient and valid training programs in strength training that lead to progressive improvements in performance.

From a classical point of view strength can be divided in maximal strength, power and strength endurance. Maximal strength, power and strength endurance are not distinct entities and bear a hierarchical relationship to one another. **Maximal strength** is the basic quality which influences strength endurance and power. On the basis of factor analysis, concentric, isometric and eccentric maximal muscle actions are not independent from one another but this might not be correct with respect to the physiological adaptations caused by training regimen with different muscle actions. Nevertheless, an increase in maximal strength brings about an increase in power and therefore in movement speed, whereas the correlation between isometric maximal strength and movement speed increases when the load gets heavier. The influence of maximal strength on strength endurance depends on the load and the time span of work, the higher the load and the shorter the working time the higher the correlation.

Power refers to the ability of the neuromuscular system to produce greatest possible impulse in a given time period. The time period depends on the resistance or the load against which the subject has to work and on the organisation of the acceleration. In other words, it is the capacity of the neuromuscular system to overcome resistance with the greatest contraction speed possible.

For the production of a great impulse an increase in force at the beginning of a muscular contraction is necessary as well as the ability to continue the developing of the already initiated force, i.e. the **rate of force development (RFD)**. Additionally for higher resistance the **maximal strength** influences the impulse production more and more.

Strength endurance refers to the ability of the neuromuscular system to produce the greatest possible sum of impulse in a definite time span by resisting "to fatigue" in long term strength performances. We know nowadays that the adequate time span for strength endurance performance is up to 2 minutes, otherwise the energy production would be more aerobic than anaerobic. In that case we would deal with endurance conditions rather with strength endurance. The intensity of work must exceed by 50% of maximum to guarantee better improvements in the anaerobic compared to aerobic capacity.

Beside concentric and isometric actions powerful movements are generated in reactive movements or in a **stretch-shortening** cycle (SSC). A stretch-shortening cycle is not only a combination of an eccentric and a concentric movement. Moreover, this type of action is a relatively independent motor quality. The quality of power production in a SSC is essentially dependent on the innervation pattern and the training state of the tendomuscular system in terms of their contractile and elastic abilities. For power performance in a SSC the correlation between maximal strength and power output are fairly low.

Nowadays we distinct fast SSC ≤ 200ms from slow SSC ≥ 200ms. From a structural point of view fast and slow SSC are independent and need different types of training methods.

Consequently the classification of training methods follows the dimensional structure of strength components. The detailed descriptions for the training of the different strength components are described elsewhere (Schmidtbleicher 2009).

The increase of the basic abilities like maximal isometric and/or dynamic strength level, RFD and strength endurance or SSC does not necessarily mean that the better values detected in the diagnostic procedures are easily transferred into the competition movements or in the case of patients in the activities of daily living.

Both types of subjects - high performance athletes as well as patients - show in general what is called a "dynamic stereotype", i.e. a rigid, very constant movement pattern with a very high reproducibility, which is very resistant for any type of change. These movement patterns are a result of thousands of repetitions of "right" or "wrong" movements and have very high levels of inter- and intramuscular reliabilities.

The top athletes want to improve their capabilities and performance levels with an increase of the basic conditioning components. The same is true for patients. Commonly, they have developed movement patterns that are accommodated to the individual restrictions of the impairments of the disease.

The key question is “How can we transfer actually developed basic capabilities into modified intra- and intermuscular coordination pattern of movements of daily living and/or in competition movements?”

If something is wrong, the next question should be

1.) What is the reason?

2.) Can we change anything?

3.) What do we want to change?

Given the fact, that we are able to change anything, what should we do?! The analysis of results in the literature show almost no updated findings that are evidence based.

One possible solution leads to the theory of differential learning. The “variation” of the movement “destroys” the dynamic stereotyped movement pattern and leads to a new and better intra- and intermuscular coordination including the improved strength components. This idea sounds good but in detail we do not have exact information. One problem is the variability of the movement. Some authors recommend a big variety and variability of the skill (1,2) whereas observations in top athletes and patients recommended fairly small changes either in load or in speed. For shot putters, discus- and javelin throwers variations of plus/minus 20% of the original load seems to be a solution. For runners uphill and downhill runs with an incline of 10° and a decline of 3° show a comparable emg-pattern compared with running on an even ground (3).

In case of patients with gait problems the use of a treadmill is very common. In that case keep in mind that treadmill running and walking is not similar to free running or walking (4). The use of additional load to the body weight – more than 8% - changes the innervation as well as the reduction of the body weight – more than 5%.

If the patients are athletes an additional problem occurs, especially in game sports. Normally one should have data from standard diagnosis programs before injury. In that case the rehabilitation should end with values, whereas the results of the tests of the different conditional components should exceed the former results by 20 – 25%. This reduces the risk of re-injuries because in a comparable situation the probability to tolerance a high load is increased.

Moreover in sports or disciplines with high interactions – like in games - it is seen very often that the higher performance after the rehabilitation cannot be used in real competition. This is mainly due to a psychological restriction that avoids the risks of hard fights. One solution could be to offer a number of skills with which competition movements are simulated in combination with unexpected disturbances. Another possibility is to solve movement tasks like landing on unever floors and/or under time limited conditions.

The use of “specific strength training”-skills will enhance the transfer of strength training effects into functional movements significantly.

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USE OF CHAINS AND RUBBER CORDS IN WEIGHT TRAINING

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Chain training involves using hooks to hang chains from both ends of a barbell. Similarly elastic bands can also be attached to the ends of the barbell. The use of either chains or elastic bands results in an increase in resistance as the barbell is lifted. When the barbell is in the lowest position of an exercise, such as the chest touch position in the bench press or the lowest position in a squat, a relatively small section of chain is added to the mass of the barbell with the rest of the chain lying on the floor. Similarly when in the lowest position of an exercise the elastic band is minimally stretched and so adds little resistance to the total mass of the barbell. As the barbell is lifted during the concentric repetition phase more and more chain is picked up off of the floor or the elastic band is stretched adding additional resistance to the barbell as it is lifted. This results in a variable resistance that increases as the barbell is lifted from the lowest to the highest position of an exercise. Conversely as the barbell is lowered from the highest to the lowest position of an exercise the resistance decreases. The end result with either training technique is an ascending force curve similar to that produced by some resistance training machines, such as variable resistance or cam machines.

This type of training is gaining popularity among some types of athletes and fitness enthusiasts. For example, chain and elastic band training is a popular adjunct to normal training among elite powerlifters with 57% and 39% of lifters incorporating chain and elastic band training, respectively, into their total training program (Swinton et al. 2009). Anecdotally these types of training techniques appear to be most prevalent in multi-joint exercises, such as the bench press, squat, and dead lift which have an ascending strength curve, or Olympic lifts where acceleration of the barbell and power are necessary for completion of a repetition.

Several different methods of hanging chain from a barbell have been developed. With the linear technique one or more chains are hung from each side of the barbell which results in an ever increasing, but relatively linear increase in resistance as the barbell is moved to a higher position of an exercise. With the double-looped technique one end of a smaller chain is attached to the barbell and the other end is attached to a larger chain that is lying on the floor. This results in a linear increase in resistance as the smaller chain is lifted, but a large increase in resistance when the larger chain begins to be lifted off of the floor. With both techniques the chain can be looped several times to increase the resistance and different sized chains can be used to vary the resistance. With the double-loop technique the change in resistance during a back squat is substantially more than with the linear technique (Neely, Terry and Morris, 2010). The double-loop technique provides nearly 2 times the increase in resistance compared to the linear technique during a back squat.

Elastic bands are used in a manner similar to chains. Larger bands or several bands can be used to increase the resistance during an exercise. It would also be possible to produce a large increase in resistance by attaching one end of a band to a non-elastic rope or cable and the other to the floor. The rope or cable would have to be long enough so that the band is not stretched at all when in the lowest position of an exercise. However, when the elastic band begins to be stretched there would be an increase in resistance.

Test-retest reliability of a chain one repetition maximum (1 RM) bench press (McCurdy et al. 2008) is high in both men (r = 0.99) and women (r = 0.93). More importantly from a training perspective chain 1 RM bench press ability significantly correlates with normal bench press 1 RM in both men and women (r = 0.95 and 0.80, respectively) indicating chain 1 RM bench press ability is a valid predictor of normal 1 RM bench press ability. Additionally, the correlation indicates if chain 1 RM bench press is increased normal bench press 1 RM will also increase (McCurdy et al. 2008).

As might be expected use of chains does change the velocity of movement during a bench press. A comparison of using 75% of 1 RM compared to using 60 % of 1 RM with chains increasing resistance to a maximal resistance of approximately 75% of 1 RM (chains adding 17.5 kg in resistance) concentric lifting velocity increased approximately 10% with the use of chains (Baker and Newton, 2009). Likewise eccentric lifting velocity was generally increased with the use of chains. The changes in velocity were likely due to the changing resistance during the concentric and eccentric repetition phases. The changes in lifting velocity could be interpreted to mean that chains are warranted when a goal of training is to lift heavy resistances in an explosive or fast manner and the eccentric unloading due to the use of chains results in a more rapid stretch-shortening cycle when switching from the eccentric to the concentric repetition phases in the lowest position in the bench press.

During a normal back squat and chain squat electromyographic (EMG) activity of the quadriceps and hamstring muscle groups and vertical ground reaction forces are not significantly different between the last repetition of 5 repetitions performed with a 5 RM resistance indicating no muscle recruitment advantage with chain training (Ebben and Jensen, 2002). When performing the chain squat approximately 10% of the mass on the barbell was removed and replaced by the chains. Ebben and Jensen (2002) also examined the effect of using elastic bands to replace 10% of the barbell mass. The use of elastic bands showed no significant difference in EMG activity or vertical ground reaction forces between a normal and chain back squat indicating no muscle recruitment advantage with elastic band training.

The use of elastic bands during a Smith machine back squat does, however show some differences from a normal Smith machine back squat (Wallace et al. 2006). Smith machine back squats were performed at 60% and 85% of normal Smith machine back squat 1 RM and with two variations of elastic band resistance at the same percentages of Smith machine 1 RM. With one variation 80% of the resistance was provided by weight plates and approximately 20% provided by elastic bands and with the other variation 65% of the resistance provided by weight plates and approximately 35% provided by elastic bands. Peak force, peak power and rate of force development were not significantly different between any of the squats performed using 60% of 1 RM. There were, however peak force and peak power differences between the normal Smith machine back squat at 85% 1 RM and the elastic band squats using both variations of resistance. In both cases greater peak force was shown with the elastic band variations compared to the normal squat. A 16% increase in peak force was shown with 80% of the resistance provided by weight plates and 20% by elastic bands compared to the normal squat, and an increase of 5% was shown with 65% of the resistance provided by weight plates and 35% of the resistance provided by elastic bands compared to 80% of the resistance provided by weight plates and 20% provided by the elastic bands. Similarly peak power was increased to 24% during the 80% of the resistance provided by weight plates and 20% provided by elastic bands compared to the normal squat, and an increase of 13% with 65% of the resistance provided by weight plates and 35% provided by elastic bands compared to the 80% of the resistance provided by weight plates and 20% provided by elastic bands. Peak rate of force development showed no significant difference between any of the squat variations. The results indicate that Smith machine squat variations using various percentages of the resistance provided by elastic bands may be of value when a major goal of training is to increase the power and peak force.

Use of chains during the Olympic lifts appears to offer no or little advantage in terms of force production or bar velocity (Berning, Coker, and Briggs, 2008; Coker, Berning, and Briggs, 2006). The vertical ground reaction forces, vertical bar displacement, bar velocity, and rate of force production are not different when using chains in the clean and snatch lifts. These variables were examined when experienced Olympic weightlifters used 80 and 85% of 1 RM and when 5% of these resistances was removed from the barbell and replaced with chains (75% 1RM + 5% 1 RM from chains, 80% 1 RM + 5% 1 RM from chains). However, the lifters reported when using chains that greater effort was required throughout the entire lift and that oscillation of the chains required greater effort to stabilize the bar, especially during the catch phrase of the snatch. This potentially could offer a psychological and possibly a physiological advantage when chains are used in training the Olympic lifts.

Training studies are equivocal concerning the use of chains and elastic bands. A 7 week training study using elastic bands demonstrated a significantly greater increase in 1 RM back squat (16% vs. 6%) and bench press (8% vs. 4%) compared to normal training (Anderson, Sforzo, and Sigg. 2008). Normal and elastic band training resistances were equated as during elastic band training 80% of the resistance was supplied by free weights with 20% supplied with elastic bands. While during a 7 week training period increases in predicted 1 RM bench press were not significantly different with chain and elastic band training compared to normal training (Ghigarelli et al. 2009). Although increases in 5 RM peak power showed a trend ($p = 0.11$) favoring the elastic band (4%) and chain (2.5%) compared to the normal training (1%).

Baseball players in the off-season training 2 days per week for 9 weeks with either a chain or no chain bench press showed similar increases in strength (McCurdy et al. 2009). Both groups trained using a linear periodization program at the same percentages of either a normal barbell bench press or a barbell bench press where all resistance (minus the barbell) was supplied by chains. A variety of upper body exercises was also performed by both training groups. Chain training resulted in increases in chain loaded and normal bench press 1 RM of 14.8% and 5.7%, respectively. Normal bench press training resulted in increases in chain loaded and normal bench press 1 RM of 7.4% and 6.3%, respectively. No significant differences between groups were noted. Subjective measures of shoulder pain and soreness were not significantly different between the two types of training. However, there was a threefold difference in subjective shoulder pain with normal training (chain training 2.5 and normal training 6.14), while subjective shoulder soreness scores were very close to each other (chain training 9.38 and normal training 10.57).

Women collegiate volleyball and basketball athletes training 2 days per week for 8 weeks with either a no chain or a chain bench press also showed similar increases in bench press 1 RM (Burnham, Rudd and McGowan 2010). Both groups performed 3 sets of the bench press per training session. The normal bench press training consisted of 80% of 1 RM for 8 repetitions, 85% of 1 RM for 6 repetitions and 90% of 1 RM for 4 repetitions. Chain training consisted of the same number of repetitions per set except 5% of the total resistance was supplied by chains (i.e. 80% of 1 RM set equals 75% of one RM with weights and 5% with chains). Both groups significantly increased normal 1 RM bench press ability, but there was no significant difference shown between groups (normal training 11.8% and chain training 17.4%) although the percentage increase favored the chain training.

Chain and elastic band training offer some potential advantages, especially in lifts with an ascending strength curve, such as increased muscle activation and increased lifting velocity. However, to date training studies indicate equivocal results in terms of 1 RM strength increases with the majority of studies showing no significant differences between normal and chain training. However, there are numerous variations in the amount of resistance that is supplied by chain and elastic band training that have not been investigated.

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SERIAL STRETCH LOADING IN RESISTANCE TRAINING

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INTRODUCTION

As strength represents in many sports an important performance affecting factor, resistance exercise has become an integral part of athlete´s training. Also in rehabilitation, namely after injuries is resistance exercise an unavoidable part of normalization of neuromuscular functions.

An overload principle formulated by DeLorme (1) more than half a century ago is still a cornerstone of all strength training programs. Muscle has to be taxed beyond its normal daily load in order to stimulate the adaptation processes resulting in increase of strength as well as in other positive health related changes.

To create an overload a muscle has to contract against resistance. This has traditionally been provided by lifting weights or in the case of isometric exercise a firm resistance. These two training modalities have been extensively studied for more than a half of century. The specific effects of different weight lifted (expressed in percent of 1RM), number of repetition in a set and number of sets is a standard textbook knowledge on resistance training. In dynamic lifting exercise the roles of concentric and eccentric contraction phase as well as their combination have been clarified and summarized (2). Recently also the importance of lifting velocity (or power produced in concentric phase), which can vary intentionally or due to fatigue and substantially affects the resistive force resulting from inertia have been demonstrated (3). In the case of isometric exercise, position specificity (predominant improvement of isometric strength in the position preferred in training) as well as the role of exposition time has been identified.

However, lifting the weights or exerting the force at zero velocity against a firm resistance have not remained the sole means of strength training. Resistance against muscle contraction can be provided by number of other modalities, e.g. elastic materials, pneumatic system, hydraulic resistance, air and water resistance, mechanical contact friction, electric non-contact resistance (e.g. Eddy current brake). Some of them in combination with specific control system may be used to create isokinetic conditions, under which resistance accomodates in order to keep movement velocity constant, regardless of force exerted. Resistance provided by each of these strength training stimuli has its specific character, namely force and power production in concentric and eccentric phase of muscle contraction as related to the time or position. These characteristics have an important impact on the training outcome. For example elastic materials, such as springs or bands, functioning on the Hooke´s law of elasticity, provide low resistance force at the beginning of the concentric movement. Resistance increases linearly with amount of extension. Though the steepness of force increase may be ameliorated or even fully eliminated by selection of material with different capabilities (spring constant) or using some specific technical solution, elastic system will never feature high initial starting force necessary to stimulate improvement of the rate of the force development, a capability of decisive importance for explosive type of sports (most of track and field events, ball games, etc). On the other hand, this strength training modality may be fully suitable for sports like swimming, where rather smooth than abrupt application of force is needed in order to avoid wasting of energy due to turbulent water flow.

If the rate of the force development is in the primary goal of the strength training, then the system providing high initial resistance under dynamic conditions should be employed. Typical examples are the weights, which provide resistance not only due to gravity, but also inertia. It has been postulated (4) that improvement of the rate of force development occurs namely after dynamic exercises performed with maximal effort eliciting high force peak at the beginning of movement. The force peak can be enhanced by performing the lifting with counter movement with maximal effort and the full concentration on changing eccentric into concentric concentration as fast as possible (Fig. 1).

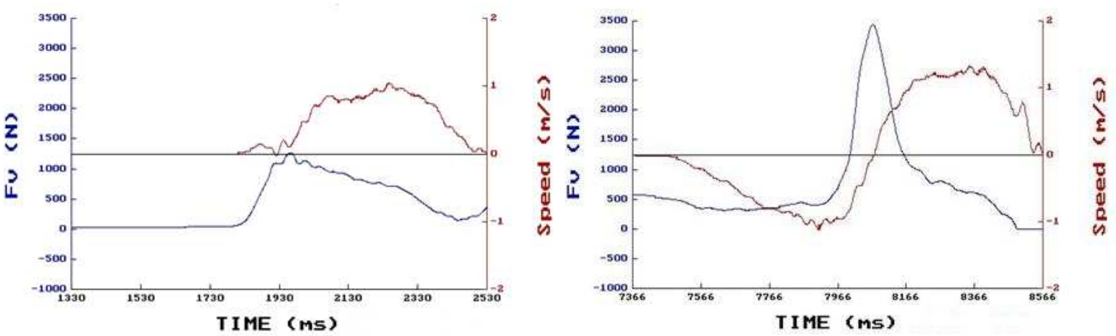

Fig. 1 Force time curve while performing bench press with maximal effort without and with counter movement.

However, during traditional weight exercise performed with counter movement, this force peaks occurs only once during a repetition. We hypothesized that imposing the force peaks not only at the turning points, but repeatedly during concentric and eccentric phase of muscle contraction, may be more efficient means for improving explosive strength. In order to test this hypothesis in a training study we have designed a system, which is capable of eliciting force peaks of controllable magnitude at preset frequency.

SERIAL STRETCH LOADING MACHINE

Leg press machine (Fig. 2) has been decided to be built as a primary model.

Fig. 2 Leg press machine based on two computer controlled linear motors

The equipment is based on a pair of powerful linear motor, capable to produce resistance up to 1800 N for each extremity. They possess a potential to accelerate at the rate of 15 g and reach maximum velocity up to 10 m/s in both directions. Controlled by the computer the system can work in active isokinetic or constant resistance mode.

In isokinetic mode pedals move at the specified velocity within preset range of motion during both concentric and eccentric phase regardless of force applied by an exerciser. In constant resistance mode instead of range of motion just starting position is set. The pedals remain in this position until the external force exceeds the present value. From this moment on the pedals start to move to the opposite direction exerting constant preset resistance.

The movement depends on the difference between resistance force and force exerted by muscles. Once the force exerted by muscles drops below the preset force, the pedals move back to initial position.

To impose a stretch during concentric contraction, movement velocity has to be reversed suddenly. Applying the same principle during eccentric phase would lead to sudden decrease of contraction force. To generate force peak and resulting stretch during eccentric contraction, velocity has to be increased rapidly. Repeating counter movements during concentric and short velocity increases during eccentric phase results in force peaks occurring at preset frequency. The amplitude of the force peaks does depend mainly on the acceleration during changing the direction during concentric phase or increasing the velocity during eccentric phase.

TRAINING STUDY USING SERIAL STRETCH LOADING

To compare the efficiency of strength training performed in classical isokinetic mode and under serial stretch loading conditions 2 groups of young fit subjects were recruited. Serial stretch loading in concentric phase was provided by 5 mm counter movements at velocity of 0.4 m/s after every 20 mm of extension movement at velocity of 0.3 m/s. During eccentric phase short 5 mm segments of faster velocity (0.7 m/s) were imposed after every 20 mm of eccentric movement at velocity of 0.2 m/s. This setup was eliciting force peaks exceeding by about 100 % the maximal voluntary contraction in given position at the rate of about 10 Hz (fig. 3).

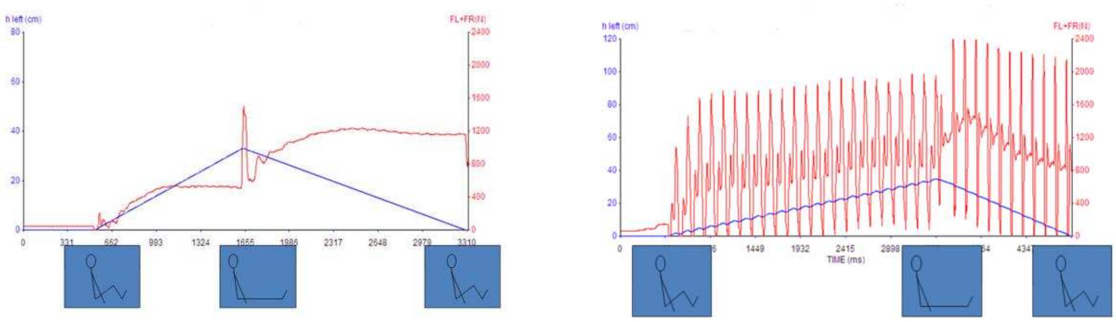

Fig. 3 Force curves during in concentric and eccentric phase of classical isokinetic (left) and serial stretch loading (right) leg press exercise performed with maximal effort.

In the isokinetic mode (control group) velocity 0.3 m/s was used in both concentric and eccentric phase.

Both groups underwent 8-week training program consisting of 3 sessions a week. In each session subjects performed 6 sets of leg press with 2 minutes rest interval. Because of the counter movements in concentric phase serial stretch loading repetitions were about 50 % longer that isokinetic ones. In order to keep contraction time comparable, serial stretch loading group did 6 repetitions as compared to 9 repetitions in isokinetic group. Each repetition was performed with maximal effort in both concentric and eccentric phases. Prior and after training period subjects performed test to estimate maximal isometric force at 70 degree, maximal isokinetic strength in both concentric and eccentric phase as well as maximal force gradient.

Results showed that both groups increased their maximal isometric strength as well as maximal strength and power during isokinetic contraction in both concentric and eccentric phases. Improvement amounted to about 20 % and was comparable with the strength training studies of similar duration. However, difference between both groups was not statistically significant. On the other hand, substantial difference has been found in improvement of force gradient (fig. 3).

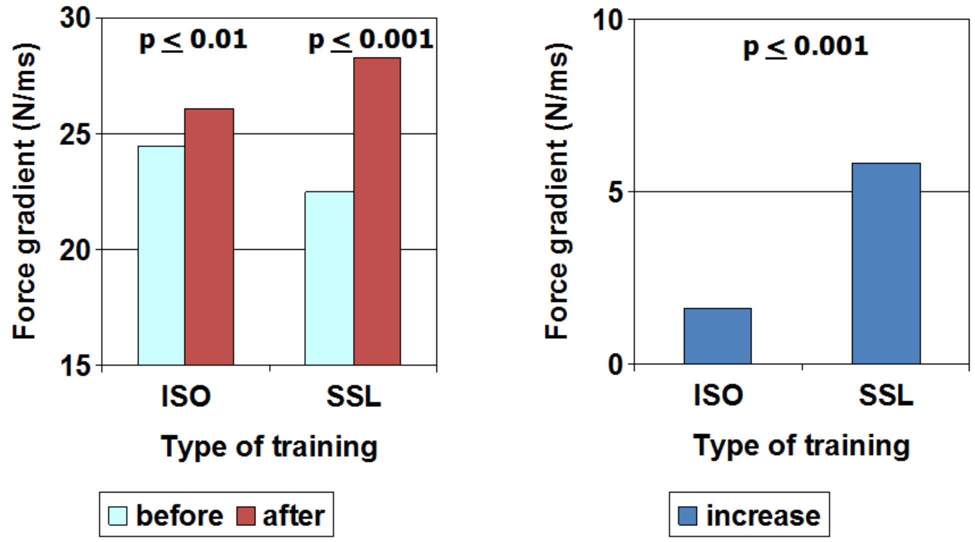

Fig. 4 Effect of 8 week training based on classical isokinetic and serial stretch loading protocol on the rate of the force development.

This finding indicates that serial stretch loading protocol is more efficient means for the enhancement of explosive strength and power. As in most of the sports, period to apply force for the acceleration of either own body or equipment is rather short (less than 200, or even 100 ms), is the ability to produce force in shortest time possible important capability, which may not only foster sport performance, but theoretically may also have a potential to prevent injuries. External forces acting on the joint are counteracted not only by passive structures as capsule and ligaments, but also by muscle controlling the movement in particular joint. However, their active contribution and increase of protective firmness threshold only takes place, if the force produced by muscle contraction increases rapidly enough to counteract the external forces resulting from injury mechanism.

Rapid application of force is also important in resuming suddenly distorted balance due to slipping or stumbling, what may decrease incidence of falling and risk of injuries.

CONCLUSION

Though serial stretch loading protocol eliciting force peaks exceeding by 100 % force produced by maximal voluntary contraction at the rate of 10 Hz in comparison with traditional isokinetic mode is equally efficient means for improvement of maximal isometric and isokinetic force, however, it has significantly higher potential for the enhancement of the rate of the force development.

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Thursday 14:00-16:00

Oral Podium Presentations I.

RUBBER BASED RESISTANCE AND THE BENCH PRESS EXERCISE: FORCE AND POWER OUTPUTS

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INTRODUCTION

The application of rubber based resistance (RBR) to traditional isoinertial resistance exercises as a method of manipulating exercise kinematics and kinetics has gained popularity within the strength and conditioning fraternity. However, the tensile properties of RBR have not been thoroughly quantified and methodological limitations confound our ability to draw conclusions on potential training applications of RBR, particularly across multiple sets. Therefore this research aims to determine whether differences exist between free weight (FW) and RBR bench press repetition and multiple set force and power.

METHODS

The tension-deformation (T-D) characteristics of six weights of RBR bands were first determined by measuring mean vertical ground reaction forces over a range of ascending and descending band deformations in 7.5cm increments using force platform data, sampled at 200Hz for 5 seconds. Subsequent to the establishment of the T-D relationship, 14 well-trained male rugby players performed three sets of six bench press repetitions under two conditions: RBR resistance contributed to either 0% (FW) or 40% (RBR40) of the total apex resistance using a 50% 1RM load. A force platform and linear position transducer (Fitness Technology, South Australia), and bench were used in conjunction with a power rack fitted with sliding safety bars. A pair of RBR bands (Power Bands, Australian Kettlebells, Victoria) were attached to either end of a barbell and anchored by the safety bars, accounting for the anthropometrical differences between participants. The force- and displacement-time data were sampled at 200Hz by a computer based data acquisition and analysis programme (Ballistic Measurement System, version 2009.1.4). Descriptive data are presented as means ± SD, and the magnitudes of the observed between-condition differences ±90% confidence limits were interpreted qualitatively according to Hopkins (1). Data is presented as mean 10% of total displacement increments for the second repetition of the first set, and mean total session values.

RESULTS

Repetition force and power across the spectrum of concentric displacement for both FW and RBR40 conditions are presented in Figures 1 and 2 respectively. Force was meaningfully greater for FW than RBR40 at 20-70% concentric displacement, and RBR40 was greater than FW at 10, 90, and 100% displacement. Power was greater for RBR40 at all loads, meaningfully at displacements of 10-50% and 90-100%. Total session data can be observed in Figure 3. Total session mean force and power were meaningfully lower for the RBR40 condition relative to FW. Peak power was meaningfully greater for RBR40 than FW, peak force was not meaningfully different between conditions.

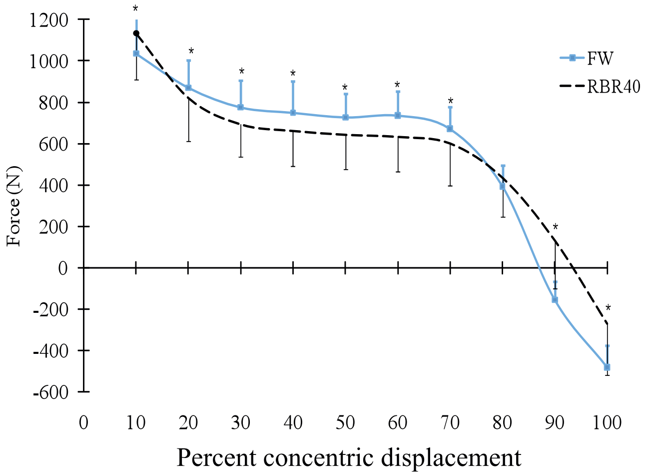

Figure 1: Mean FW and RBR40 repetition force relative to concentric displacement
* = practically meaningful difference

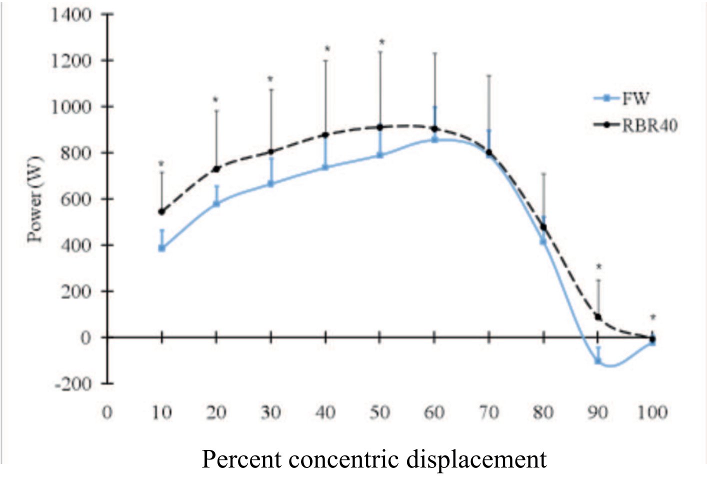

Figure 2: Mean FW and RBR40 repetition power relative to concentric displacement
* = practically meaningful difference

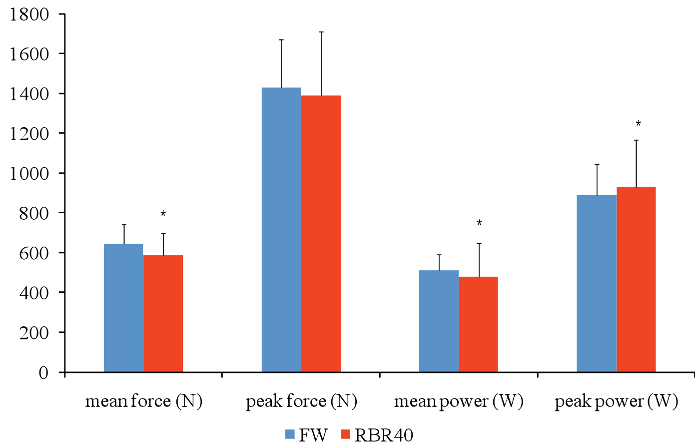

Figure 3: Total session mean and peak force and power outputs for FW and RBR40 conditions

DISCUSSION and CONCLUSION

The repetition data add to previous research but in context to the bench press exercise. Although a longitudinal study quantifying the relative efficacy of RBR as a training modality is needed, it appears that RBR provides an alternative training modality that positively influences mechanical power ouputs across the displacement spectrum, thus adding to the practitioners' repertoire of potentially useful training stimuli. Greater peak power outputs across a session support such a contention.

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IS THE EXISTENCE OF THE STICKING REGION IN BENCH PRESS THE RESULT OF DIMINISING POTENTIATION OR A MECHANICAL POOR FORCE REGION?

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INTRODUCTION

In strength training for different sports, the bench press is one of the most popular exercises for the upper body. In bench press at maximal and sub-maximal loads a sticking region occurs during the upwards phase [3,4]. This sticking region is often seen as the weakest link in the upward movement at which an attempt potentially will fail [2]. The cause of this sticking region is still unclear. In some studies it was hypothesized that during the sticking period a poor mechanical force position occurs in which the lengths and mechanical advantages of the muscles involved were such that their capacity to exert force was reduced in this period [1,3]. Other studies suggest that the start of a sticking period occurs due to the disappearance of enhanced force (potentiation) at the start of the concentric movement. As the strength is diminishing, a delayed neural reaction occurs and stimulates muscles to activate more to the increasing demands of the attempt. This results in overcoming the sticking region [6]. Therefore the aim of this study was to investigate if the occurrence of the sticking region was a result of diminishing potentiation or the result of a mechanical poor region in which the muscles can produce less force.

METHODS

Twelve male subjects (age 21.7 ± 1.3 yr, mass 78 ± 5.8 kg, height 1.81 ± 0.05 m.) with at least one year of strength training participated in this study. Every subject was tested in 1RM and afterwards in isometric contractions (3 sec) in bench press in eleven different distances between the barbell and the sternum (0–28 cm), simulating the whole range of motion during the upwards movement around the sticking region. Every height was tested twice in a random order. The maximal force output was measured with a force platform placed under the bench. EMG was measured of the triceps brachii, the anterior deltoid, the sternal portion of the pectoralis major and the biceps brachii. The highest produced force during one second in each attempt at the different heights was used for further analysis.

RESULTS

The average 1 RM of the subjects was 104 (±8.9) kg.

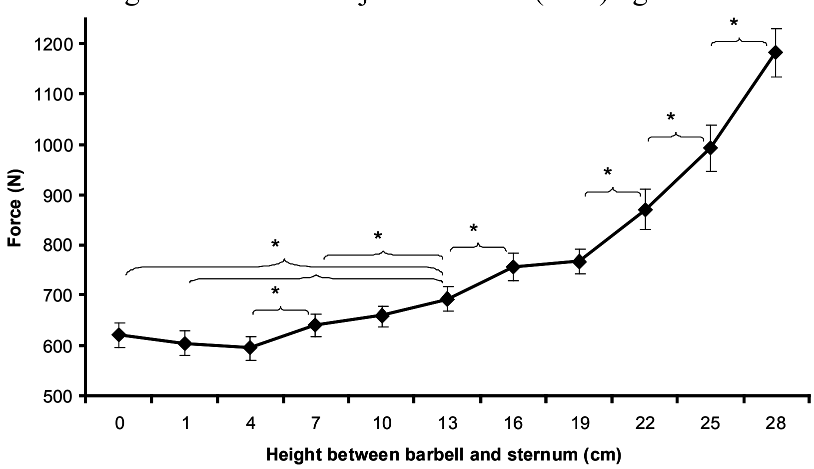

Fig.1 mean force output at the various distances between barbell and sternum * significant differences between these two force outputs at $p<0.05$.

There were significant differences found in force output at the various distances between the sternum and the barbell with the isometric contractions. The lowest maximal force output was at 1 and 4 cm and after 4cm the force output increased radically (Fig. 1). The mean muscle activity was also different at the different heights (Fig. 2). The muscle activity of the deltoid muscle decreased while the triceps activity increased from 0 cm to 28 cm. The pectoralis activity firstly increased with increasing height, but from 19cm up over the activity decreased. The biceps activity was approximately the same during the tests at various heights.

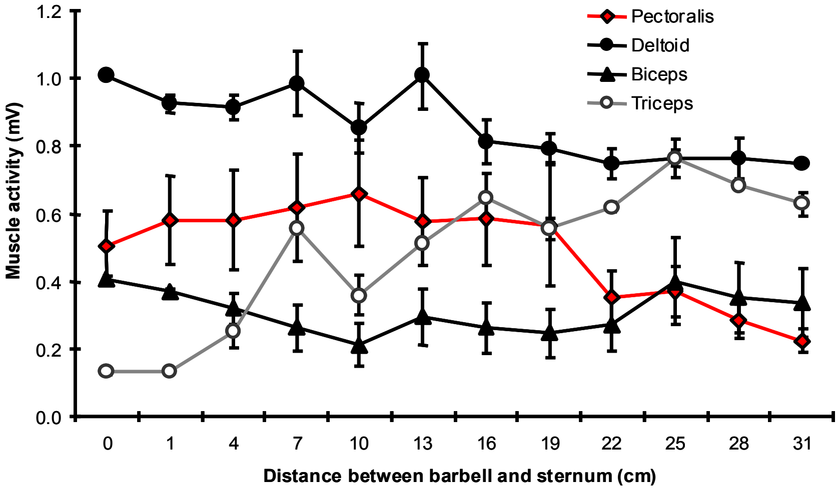

Fig.2 mean muscle activity of the different muscles at the various distances between barbell and sternum.

DISCUSSION

This study showed that the force output is significant lower the first 10 cm during isometric contractions (Fig. 1) which is in line with the earlier findings about the occurrence of the sticking region in maximal 1 RM bench pressing [5,6]. However, about the muscle activation the opposite is found when compared with the earlier studies [5,6]. In these studies the muscle activity of the pectoralis and deltoid muscles increased after the sticking region while in the current study both muscles decreased their activity. The opposite was found for the triceps muscle i.e. increase in the current study and a decrease in earlier studies. It indicates that the theories of diminishing effect of elastic components, potentiation and delayed muscle activation can't explain the occurrence of the sticking region. It seems that the sticking region is the result of a poor mechanical force position, which can be caused by the resultant moment arm about the shoulder joint [1] and/or elbow joint [6]. Since only the triceps muscle activity increases with increasing height it is plausible that this muscle is responsible for 'stucking' or getting out of the sticking region. Clearly, new studies are needed to verify these findings.

CONCLUSION

It was found that diminishing effect of elastic components, potentiation and delayed muscle activation could not explain the existence of the sticking region when conducting isometric contractions at different heights around the sticking region. It seems that the sticking region is the result of a poor mechanical force position that can be caused by changing resultant moment arms around the elbow and shoulder joint.

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EFFECT OF DIFFERENT JOINT ANGLES ON THE KNEE FLEXOR AND EXTENSOR RATE OF FORCE DEVELOPMENT DURING MAXIMAL ISOMETRIC CONTRACTION

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INTRODUCTION

Alteration in maximal isometric strength with change in joint angle is well known phenomenon [1, 2]. In addition to the assessment of maximal isometric force, rate of force development (*RFD*) is very often estimated, and according to some authors it represents a separate muscle's ability, while to the others it is inherent and dependent on maximum force [2]. Along with this dilemma, which is present partly due to different methods and parameters used to estimate this parameter, it is still mostly unknown if and in which way changes in joint position influence *RFD*. Earlier efforts were made to explore this relationship, but within different range of angles and by using either *RFD* or level of EMG activation [1, 3]. In order to investigate before mentioned dependency, we designed an experiment where maximum strength (F_{max}), absolute (*RFD*) and relative (*RRFD*) rate of force development have been measured at different knee joint angles. The purpose of this study was to test the hypothesis that RFD's angle dependency is not influenced only by the applied assessment methods, but also by selected muscle group.

METHODS

20 male physical education students (age 24±4, weight 81±8kg and height 1.82±0.6m) participated in the study. Test was performed on the Kin Com isokinetic dynamometer (Chattanooga, TN, USA). F_{max} and *RFD* were obtained from the dominant leg (18 rights and 2 left) during the maximal isometric contractions at angles of 100, 120, 140 and 160 degrees in knee extension. *RFD* was normalized with respect to F_{max} to obtain *RRFD*.

RESULTS

Results of between analysis (muscle group, angle) for F_{max}, *RFD* and *RRFD* are presented in the figures 1 and 2.

Within group analysis (angle) for knee extensors *Fmax* revealed significant differences ($p<0.01$) among all tested positions, with highest forces generated at 120°. *RFD* obtained at 120° (highest) and 160° (lowest) were different ($p<0.01$) from those obtained at the other angles. Opposite to F_{max} and *RFD*, *RRFD* increased along with knee angle increase, and highest values were obtained at angles of 140° ($p<0.05$) and 160° ($p<0.01$).

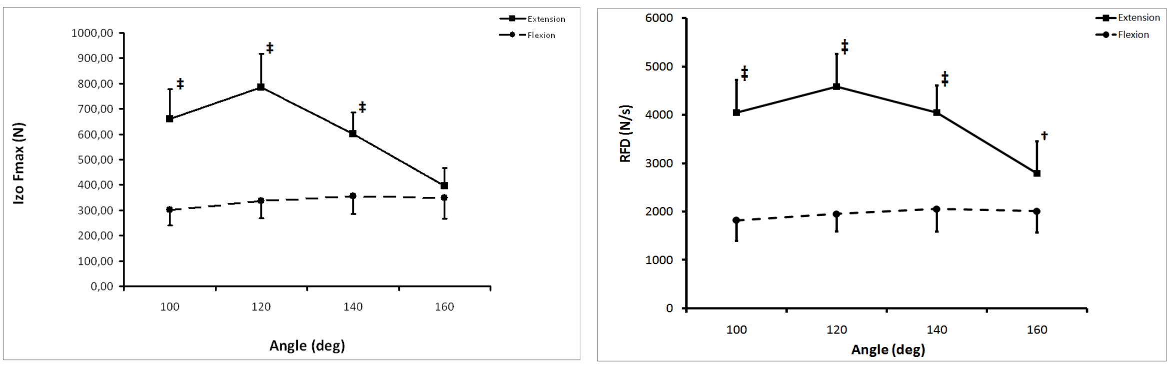

Fig. Maximum force (*Fmax*) of knee extensors and flexors obtained at angles of 100, 120, 140 and 160 degrees of knee extension (left). Rate of force development of knee extensors and flexors obtained at angles of 100, 120, 140 and 160 degrees of knee extension (right).
Between muscle groups analysis: † $p<0.05$, ‡ $p<0.01$

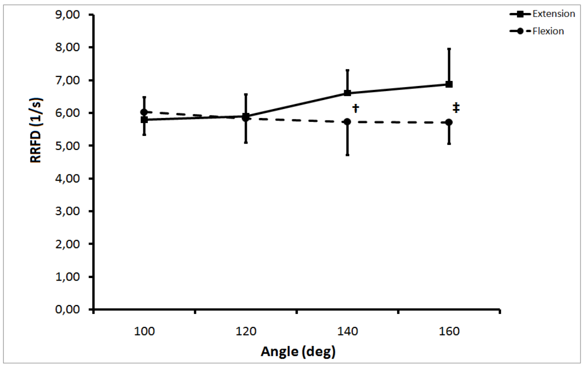

Fig.2 Relative rate of force development (*RRFD*) of knee extensors and flexors obtained at angles of 100, 120, 140 and 160 degrees of knee extension. Between muscle groups analysis: † $p<0.05$, ‡ $p<0.01$

As for knee flexors, all of three variables (except F_{max} and *RFD* obtained at 100°, $p<0.01$ that were different from 140° and 160°) remained mostly invariant throughout the range of selected angles.

DISCUSSION

The present study investigated relationship of neuromuscular functions and different knee joint angles. All variables used in this experiment have shown to be muscle specific. The obtained results indicate that with the change of joint position *RFD* changes the same way as F_{max}, even for the knee flexors, although those changes weren't as visible and significant as for knee extensors. This finding supports previous findings [2] about *RFD* being muscle-force dependent. On the other hand, when we want to estimate explosive properties of tested muscles, we have to normalize *RFD* by F_{max}, which has shown up to be muscle-force independent. And, while other two variable showed to have polynomial relationship (function), *RRFD* had linear relationship among selected angles and showed that knee extensors *RRFD* increased toward shorter muscle lengths (e.g. larger angles), while flexors *RRFD* remained invariant throughout the range of joint positions.

CONCLUSION

The present study revealed that *RFD's* is not only angle dependent but is also significantly influenced by selected muscle group. This study also revealed the influence of knee extensors biomechanical characteristic to its relative *RFD* and that therefore the choice of joint angle could possibly affect the external validity of isometric strength testing.

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Acknowledgements: The study was supported in part by a grant No.145082B from the Serbian Research Foundation.

NEUROMUSCULAR RESPONSES TO DIFFERENT LOADING PROTOCOLS USING PNEUMATIC AND WEIGHT STACK DEVICES

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INTRODUCTION

It is well known that specific type of strength loadings can lead to distinct acute responses and long term adaptations of the neuromuscular system. This forms the base for different training programs and periodizations. However, scientific information is limited about the acute effects of different methods that produce resistance. Previous studies have usually compared free weights or weight stack (WS) devices but pneumatic (P) resistance devices have been featured in only a few studies [1,2]. Neuromuscular responses to various resistance methods have traditionally been examined by use of electromyography (EMG) and several force output parameters. To the best of our knowledge, electrical stimulation has not been used to differentiate between central and peripheral fatigue in the comparison of different resistance devices. Different devices might have large variations in the resistance-angle curve, and thus, they may allow different angular velocities by modifying accelerations. Therefore, the purpose of this study was to a) examine single repetition loading characteristics and b) acute neuromuscular responses after hypertrophic, maximal strength, and power loadings performed with P and WS devices.

METHODS

15 healthy (20-35 years) men volunteered as subjects. None of the subjects had any regular weight training background. In the first session they performed explosive single repetitions using 20%, 40%, 60%, 80% and 100%1RM loads on both P (Hur 5530, Hur Ltd., Finland) and variable resistance WS (D200, David Sports Ltd., Finland) knee extensor devices in a seated position. In the following sessions they completed three different loadings using both devices. The range of the knee extension motion was 60° to 180° with a hip angle of 110°. Loadings consisted of hypertrophic (5x10RM with 2 min. rest between sets), maximum strength (15x1RM, 3 min. rest), and power (5x10, 40%1RM with 3 min. rest) training bouts. Acute loading responses were assessed by measuring maximal isometric voluntary force and rapid isometric force development, resting single- and superimposed twitch force (to determine activation level), muscle activity (EMG), and by taking finger-tip blood samples for blood lactate analyses before and after loadings.

RESULTS

Single repetitions: The greatest forces were reached on WS at 100°-120° and 120°-140° knee joint angles compared to the P device, and the force-angle curves of these two devices differed significantly ($p<0.001$ and 0.05) but were similar at ~160°-180° knee angles. EMGrms of the quadriceps muscles were initially (60°-80°) higher ($p<0.05$-0.01) during 20-60%1RM load on the P than on the WS device. With 40-100% 1RM load, accelerations were positive from ~60° to 160° using WS. However, on the P device initial high acceleration was observed at 60°-80° knee joint angles but it was followed by oscillating accelerations between positive and negative values. In the beginning of the movement, accelerations were 4 to 10 times greater on the P device with all loads as compared to WS.

***Hypertrophic loading**:* Maximal isometric voluntary force (-37%) and resting twitch force (-63% (P) and -71% (WS)) decreased significantly ($p<0.001$) during the hypertrophic loadings on both devices.

Maximal EMGrms increased (+26%) significantly ($p<0.01$) on WS. Relative changes in resting twitch force differed between the devices significantly ($p<0.05$) after hypertrophic loading. (Fig.1)
***Maximum strength loading**:* Maximal isometric voluntary force decreased ($p<0.05$-0.001) on both devices. Resting twitch force response (-17%), relative activation level (-10%), and maximal EMGrms decreased (-19%) during maximum strength loading on WS only ($p<0.05$-0.01). (Fig.1)
***Power loading**:* Maximal isometric voluntary force (-13%) decreased significantly ($p<0.01$) on the P device but not on the WS device. Resting twitch force responses were significantly ($p<0.05$-0.01) lower after loadings on both devices. In addition, relative activation level (-7%) and maximal EMGrms (-11%) decreased significantly ($p<0.05$) during power loading on WS only. (Fig.1)

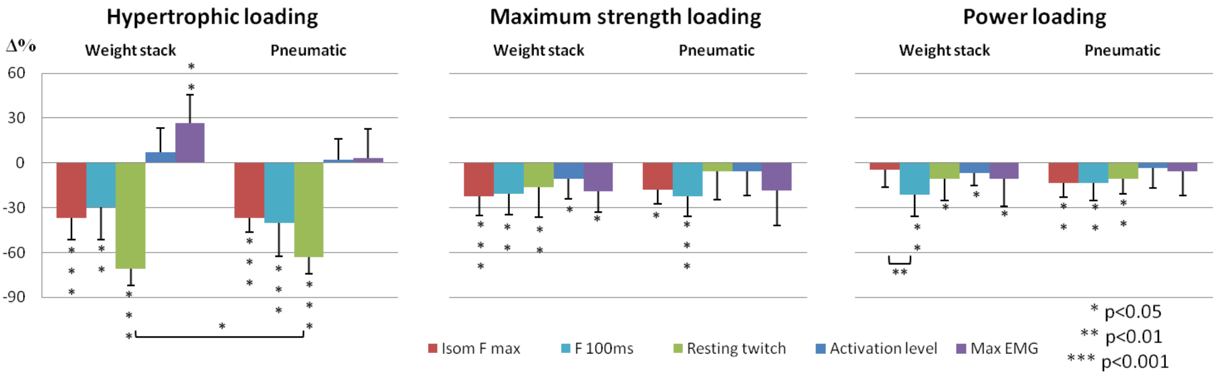

Fig.1 Relative changes of measured parameters after different loadings on both devices.

Blood lactate increased ($p<0.001$) progressively (~10 mmol/L) during the hypertrophic loading on both devices but maximum strength and power loadings did not lead to increased blood lactate.

DISCUSSION

The present study showed that maximal isometric force and rapid force production decreased during voluntary contraction after hypertrophic and maximum strength loadings on both devices. However, decreased force production was specific to rapid actions following WS power loading. The results also showed that peripheral fatigue as assessed by the resting twitch force was greater using WS compared to P following hypertrophic and maximal strength loadings. These findings may have been caused by greater resistance from ~60° to 160° angles, and therefore, higher muscular tension, using WS. Furthermore, greater central fatigue (activation level) was induced by WS during maximal strength and power loadings, which may also be due to the observed greater resistance. It appears that, although maximal strength and power loadings using P consisted of maximum effort, the higher acceleration/velocity at the beginning of the movement was not that effective in inducing central fatigue as WS's higher resistance in our untrained subjects. Nevertheless, higher velocities used repeatedly during training may lead to specific long term velocity improvements, but these features need more research.

CONCLUSION

It appears that, at least in untrained subjects, WS induces greater levels of peripheral fatigue than P during hypertrophic loadings and it also led to large central fatigue during maximal strength and power loadings. Power loading on the P device induced decreased maximal strength and rapid force production, while the respective power loading on the WS device was sensitive to led to the decreased rapid force production only.

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ACTION TYPE SPECIFIC EFFECTS FROM CONCURRENT EMG FEEDBACK FROM VASTUS MEDIALIS IN FEMALES

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INTRODUCTION

In some muscle groups, strength is limited by a non-optimal neural activation despite maximal effort (Behm et al. 2002). This deficit is especially apparent for eccentric muscle actions (Westing et al. 1990). With strength training, improvements in neural activation have been suggested to occur mainly due to increased supraspinal input to the motoneurone pool (Nordlund Ekblom, 2010). Providing feedback of electromyographic activation is one possible means by which improvements in neural activation could be enhanced. The aim of the current study was to investigate effects of myofeedback on muscle activation and strength in maximal voluntary lengthening versus shortening knee extensions.

METHODS

15 females with no prior on ongoing resistance training experience volunteered to participate in the study. Subjects were seated upright with 90 deg hip flexion angle in a isokinetic dynamometer (Isomed) which controlled knee angle. After initial warm up, subjects performed two sets of maximal voluntary concentric and eccentric muscle actions. In each set, three MVC trials at 20 deg/s over 60 degrees range of motion were given for each action type. MVC trials were separated by 45 s, action types by 5 minutes and sets by 5 minutes of rest. After the first set, subjects were randomized to either a control group (n=8) or an intervention group (n=7). In the second set, subjects in the control group performed tests identical to the first set, whereas the intervention group performed the same tests as in the first set, but now with concurrent feedback of the rectified EMG rms from the vastus medialis allowing them to continuously compare their activation of vastus medialis in the ongoing MVC with that of the prior. Knee extensor strength and the root mean square of the surface electromyografic activity from vastus lateralis, vastus medialis and hamstrings were measured over a 2-s window in the middle of the range of motion.

RESULTS

The intervention group improved their knee extensor strength by 11.8% from the first to the second set whereas the control group showed no significant change (-2.2%). The changes in strength did not differ between action types. The EMGrms of the vastus medialis was significantly improved by feedback in lengthening (15.2% for the intervention group versus -8,0 % for the control). In shortening MVC:s, no difference was seen between feedback and control. For the vastus lateralis, changes from the first to the second set did not differ between the intervention group and the control group. For the hamstrings, EMGrms was very low and not significantly different between action types. The hamstrings EMGrms increased in the feedback group by 10.9% as compared to -4.1% for the control group.

DISCUSSION

While the current study suggests that concurrent EMG feedback can acutely improve strength output and muscle activation, the elements of EMG feedback were probably not optimal since there was a slight increase also in antagonist activation with feedback. The results of this study suggest that ongoing feedback of knee extensor activation may be a viable tool for improving the quality of strength training, especially in eccentric muscle actions. This action type specific responsiveness was expected since optimal voluntary activation is usually more difficult to achieve in eccentric muscle actions (Westing et al., 1990). Future studies should address whether training with EMG feedback results in sustainable improvements in ability to activate the muscle, and whether such improved ability can be successfully transferred to a similar though not identical strength demanding task.

CONCLUSION

The results of this study show that providing EMG feedback can result in acutely improved strength output in maximal voluntary efforts. Before recommending implementation of EMG feedback in resistance training paradigms, its long term effects needs to be scrutinized.

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USING INERTIA MEASUREMENT UNIT (IMU) FOR EXERCISE ANALYSIS.

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INTRODUCTION

Motion analysis technology (i.e. videography, optical motion capture, electromyography and force plates) have been utilized by sports scientists in laboratory based environments to assess the kinematics and kinetics of athletic movements (e.g. running, jumping, kicking and throwing) (1). These systems are valid and reliable, but are limited to controlled laboratory settings. Emerging wireless technologies like an inertia measurement unit (IMU) have the capability to assess three-dimensional (3D) athletic movements in the field and weight-room based environments. Wireless 3D technology may allow for accurate assessment of dynamic exercises (i.e. sprinting, jumping, throwing, kicking and squatting) during training and game type situations. These IMU systems are relatively untested in terms of assessing the above movements; therefore must be validated before being utilized in practice. So, the aim of this study was to investigate the utility of an IMU system in term of motion analysis, and the subsequent reliability of the measurements.

METHODS

Sixteen healthy subjects (22±3 yr, 1.76±0.12 m, 72±13 kg) participated in this study and were tested twice, one week apart, following the same exercise modalities. After a standardized warm-up and familiarization with movements, they performed ten dynamic exercises allocated in four categories:

1. Vertical jumps: squat jump (SJ), counter movement jump (CMJ), drop jump (DJ) and six continuous jumps (6CJ);
2. Horizontal jumps: standing broad jump (SBJ), 5 alternate bounds (5AB) and 5 hops (5H);
3. Change of direction: quick change of direction (QCD) and distance change of direction (DCD)
4. Twenty meter sprint (SPRINT).

Three trials were undertaken for the "single impulse" exercises and two trials were for the "multi-impulse" exercises. Three minutes recovery occurred between trials and exercises. An inertia movement unit (Inertia Link, Microstrain, USA) was attached to an elastic belt on the subject's back, close to the center of mass (CM) position. Three axis acceleration and three angle rate signals were recorded at 100 Hz. The signals were thereafter analyzed using customized Exercise Labview Applications (ELA) (Labview 8.5, National Instrument) specifically developed for each exercise. Each ELA had a common part including the orientation matrix that was used to define the device relative orientation. This matrix was essential to obtain vertical (z), lateral (y) and horizontal (x) body acceleration (A), velocity (V), displacement (D) and power (P). For each ELA, a specific program was developed in order to split the exercises into specific parts and to quantify the parameters of interest. In this study, we have specifically focused our analysis on impulse and flight phases. Impulse can be divided into an eccentric phase (CM lowering) and a concentric phase (ascending CM). Classical descriptive statistics were used in the present study. Inter-session reproducibility was measured with a specific coefficient of variation (CV)(2). A dependent t-test was used to determine significant differences.

RESULTS

Using an IMU enables many measurements for each exercise to be quantified. Indeed, peak and average values could be calculated for each variable (A, V, P, D) for the three axes and during the different parts of the movement. Resultant velocity, movement orientation, stride frequency, movement phases duration, reactivity index, stiffness could also be extracted from the IMU. Summarizing all possible measures is beyond the scope of this abstract, but included are a few examples. Figure 1 compares Vx and Vz during SBJ and CMJ. While they are both unweighted leg power tests, they present very different curve shapes with very different peak values, especially in the concentric phase. Differences can also be observed for eccentric and concentric phases duration as well as for CV's.

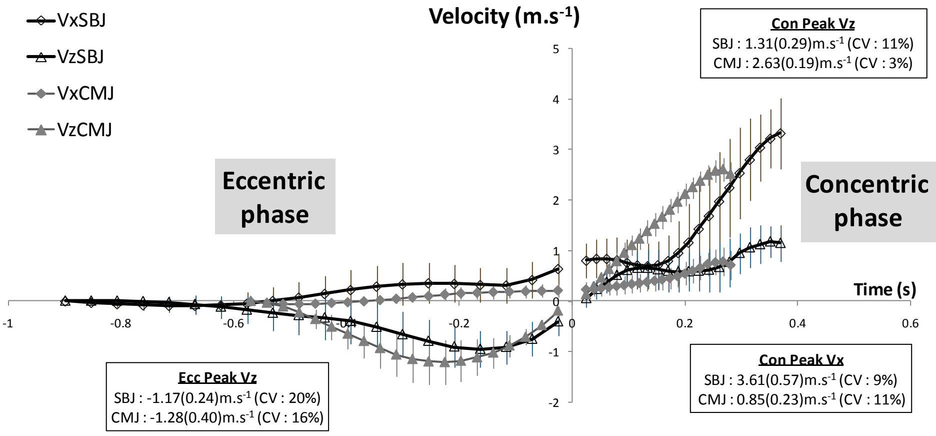

Fig.1 Curve analysis representing the evolution of Vx and Vy during eccentric and concentric phase for SBJ and CMJ. Main peak values and CV are also presented.

Reliability of the IMU system was also investigated, the inter-session reproducibility appeared to be acceptable for phase durations and velocity, especially in the main exercise axis (i.e. Z for CMJ and X for SBJ) with most CV's <10%. Reproducibility was moderate for A (6-30%), moderate to weak for P (7-33%), and weak for D (12-97%). During long duration exercises like SPRINT, 5AB, 5H and 5CJ, we have had frequently observed drift of D, V and P signals. An example is presented in Figure 2.

DISCUSSION

This study confirmed that wireless IMU systems offer very interesting options for the assessment of sport specific movement as they allow 3D motion analysis. Portable and very light, such devices can be used in the field, far from controlled laboratory settings. An amazing amount of analysis is possible with such technology from detailed curve analysis to the computation of average and peak values in three directions. However, inconsistence observed in some results could most likely be attributed to technological weakness that needs to be improved. Most troublesome were; noise from the low sample frequency (100hz), lost data due to the wireless system, orientation error due to gyro saturation and signal drift due to single and double integration.

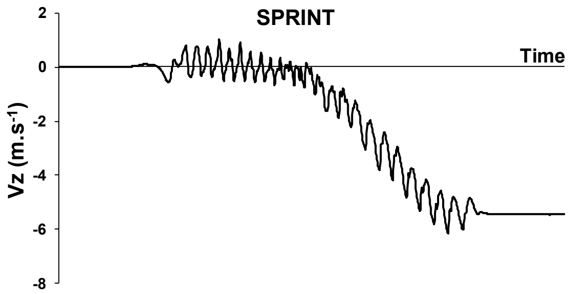

Fig.2 Drift of Vz signal during SPRINT test due to orientation error.

CONCLUSION

The present study confirms the utility of IMU technology in exercise analysis. However, technological improvements are still needed prior to meaningful, accurate and reliable data can be generated.

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EFFECTS OF COMBINED STRENGTH AND ENDURANCE TRAINING ON DYNAMIC STRENGTH, WALKING PERFORMANCE AND BALANCE IN AGING MEN

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INTRODUCTION The ability of aging humans to perform activities of daily life is strongly related to maintenance of main elements of health related physical fitness (i.e. aerobic capacity, strength production, balance and mobility) [1], [2], [7]. However, not only maximal muscle strength or aerobic capacity, but also explosive strength production of the leg extensors, is related to several activities of daily life and work tasks, for example, walking speed, balance and aging workers' ability to cope with their work especially in physically demanding occupations and in the prevention of falls [4], [5], [8]. The purpose of this study was to examine effects of strength, endurance, and combined strength and endurance training on isometric and dynamic muscle strength, walking performance and balance capability in aging men.

METHODS This study examined the effects of the 21-week twice weekly strength (ST), endurance (ET), combined (2+2 times a week) (SET) training period on neuromuscular, endurance and walking performances and balance. A group of 108 healthy men (56.3 ± 9.9 years) were divided into three training (ST; n = 30, ET; n = 26, SET; n = 31) groups and controls (C; n = 21). ST performed supervised total body ST two times a week (including e.g. 2 exercises 2 times a week for the quadriceps femoris and 1 exercise 2 times a week for the hamstrings and upper extremities) with training loads of 40-85% of the maximum force for 21 wks. ET performed supervised ET two times a week by bicycle ergometer and the intensity of endurance training performed was progressively increased and based on the aerobic performance tests (aerobic and anaerobic threshold for 21 wks. [3]. SET performed both two strength sessions and two endurance sessions a week in separate days. Muscle strength (MS) was measured by bilateral concentric 1RM and explosive leg presses [kg] (1RMleg, 50%1RMleg). During dynamic 1RM and 50% explosive leg and hip extensions EMG were measured from quadriceps muscles a) vastus lateralis (VL), b) vastus medialis (VM) and c) rectus femoris (RF) of the right leg. Ten meter walking test time at maximal velocity was performed carrying a 10.2 kg bag in each hand during the walking. (10WALK). Static balance was measured using computerized posturography as a force platform method and dynamic balance by moving the cursor on the monitor at the straightest possible line from box to next box etc. by altering weight bearing to the same force plate used in static test to record the shortest possible dynamic test distance (mm; DYN.D). Oxygen uptake was measured by using bicycle ergometer test at pedaling rate of 60 rpm, the first 2-min stage of the test at intensity of 50 W and it was increased by 20 W every second minute until exhaustion. The participants continued cycling until volitional exhaustion. The exact time of exercise was described in minutes and seconds. Peak VO2 ($VO2_{peak)}$ was measured breath by breath and averaged in 60 second intervals. Statistical significances were expressed as *$p<0.05$, **$p<0.01$, ** $p<0.001$ and Ns as non significant.

RESULTS Concentric 1RM improved significantly in ST of 21 % ($p < 0.001$) and in SET of 22 % ($p < 0.001$) (Fig. 1) and 50%1RMleg improved significantly from 0 to 21 weeks in ST of 7.5 % ($p = 0.005$) and 10.2 % in SET ($p < 0.001$), while the increases in C remained minor. Increases in 1RM EMG of vastus lateralis between weeks 0 and 10.5 and also between weeks 0 and 21 occurred in ST (17 ± 31 %, $p = 0.009$; 26 ± 40 %, $p = 0.028$) and SET (21 ± 19 %, p = < 0.001; 20 ± 33 %, $p = 0.002$) respectively. 1RM EMG of vastus medialis showed significant increases between weeks 0 and 10.5 and also between weeks 0 and 21 in ST (24 ± 33 %, $p = 0.001$; 25 ± 34 %, $p = 0.003$) and SET (15 ± 17 %, $p = 0.001$; 23 ± 36 %, $p = 0.002$). VO_{2peak} increased in ET of 12.5 % ($p = 0.001$) and in SET of 9.8 % ($p < 0.001$), 10WALK decreased from 0 to 21 weeks in ST (-7.7 ± 10.4 %, $p < 0.001$) and SET (-5.3 ± 7.2 %, $p = 0.003$), DYND decreased in ST of

-10.3 % ($p = 0.002$) and -8 % in SET ($p = 0.028$) (Fig. 2) occurred, while the changes in C remained minor. DYND correlated significantly with 1RM at 21 week in SET and ($r = -0.38$, $p = 0.04$) and at weeks 0, 10.5 and 21 in the total group of ST+SET (from $r = -0.29$, $p = 0.028$ to $r = -0.36$, $p = 0.006$). Changes of DYND (0 - 10.5 weeks) correlated significantly with changes of 50%1RMleg (0 - 10.5 weeks) in ST ($r = -0.49$, $p = 0.018$). The absolute values of DYND correlated borderline significantly with 50%1RMleg at weeks 0 and 21 in ST ($r = -0.38$, $p = 0.077$ and $r = -0.37$, $p = 0.080$), respectively.

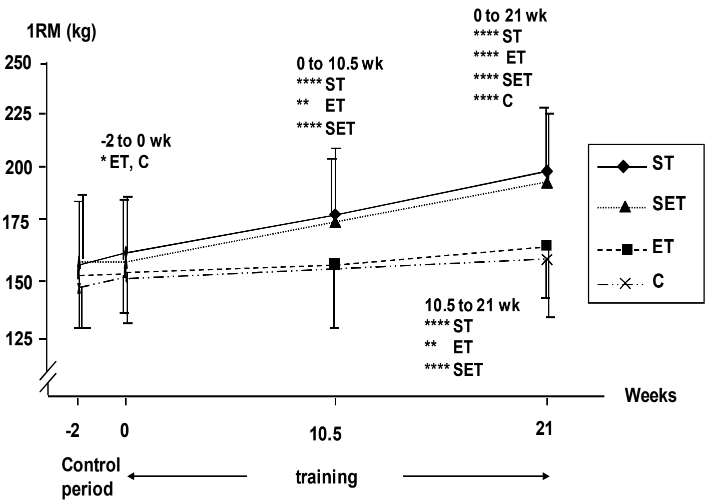

Figure 1. Bilateral one repetition maximum (1RM) of the leg extensors during the control and training periods in the strength (ST)-, endurance (ET)- and combined (SET) training groups, and control (C) group. * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$.

DISCUSSION The present results showed that our aging men demonstrated training induced specific increases in strength levels of the trained muscles both in the ST and SET groups and in peak oxygen uptake both in ET and SET after the 21- week training period. However, strength and combined training in aging men can lead not only to large increases in maximal and explosive strength of the leg extensors muscles, but also to improvement in their walking speed with the load. Furthermore, our results showed large improvements in the dynamic balance capacity and its relationship with maximal and explosive dynamic strength production and of the leg extensors in the ST and SET groups. Furthermore, the recent studies concerning strength and combined training (as well as multi modal balance and coordination training) suggest that combined training is the most beneficial training mode for the balance improvements [2], [6], [7]

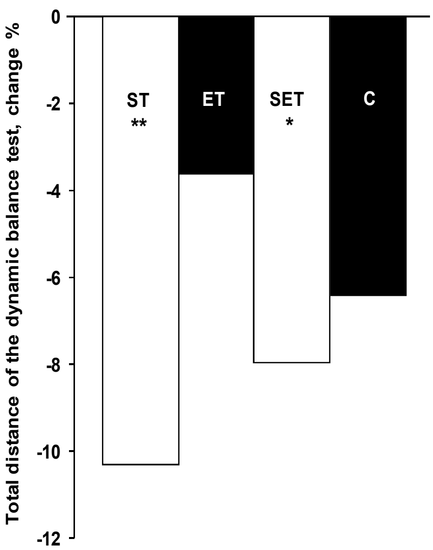

Figure 2. Relative changes of total distance of the dynamic balance test after the 21-week training period in the strength (ST)-, endurance (ET) -and combined (SET) training groups, and control (C) group. * $p < 0.05$ and ** $p < 0.01$

CONCLUSION Training-induced improvements in maximal and explosive strength and dynamic balance may be beneficial even in the prevention of falls. Strength and combined training–induced increases in maximal strength and endurance seem to be of value to aging men, but there are obviously other factors that relate to improvements in dynamic balance capacity.

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DYNAMIC BALANCE CONTROL AFTER PNEUMATIC AND PLYOMETRIC TRAINING

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INTRODUCTION

Dynamic balance control has been shown to be related to the ability to produce force as fast as possible [1] which suggests the importance of explosive strength training in improving balance control. In plyometric form of exercise, reflex loop may be connected to efficiency of the stretch-shortening cycle type of movement [2]. On the other hand, variable resistance training (e.g. pneumatic) may improve muscle activation more efficiently during larger range of motion with different muscle lengths [3]. Whether these two different training modes when performed explosively have similar effects on balance control is not clear at present. Therefore the purpose of the present study was to compare 12 week plyometric and pneumatic explosive strength training and their benefits on dynamic balance control.

METHODS

30 male subjects (21-70 years) participated in the study and they were divided into two training groups (plyometric; PLY n=14 and pneumatic; PNE n=16). Before the measurements, subjects had a short familiarizing period in order to reduce the amount of learning. Dynamic balance control [1], maximal drop jump performance from optimal dropping height in a sledge apparatus and maximal (MVC) and rapid knee extension torque (RFD) production (0-200ms) were measured in the beginning, during (4 and 8wk) and after the 12 weeks of explosive strength training. H-reflex sensitivity during rest (Hmax/Mmax) and during drop jumps (H/M20%) and passive twitch response in the beginning and after the 12 weeks training period were measured.

RESULTS

In dynamic balance control test (Fig 1.) the displacement in anterior-posterior direction decreased significantly already after 4 weeks of both training protocols (PLY -35±14%, $p<0.001$ and PNE -30±12%, $p<0.001$). There were no major changes in balance control during the rest of the training period as compared to 4 weeks.

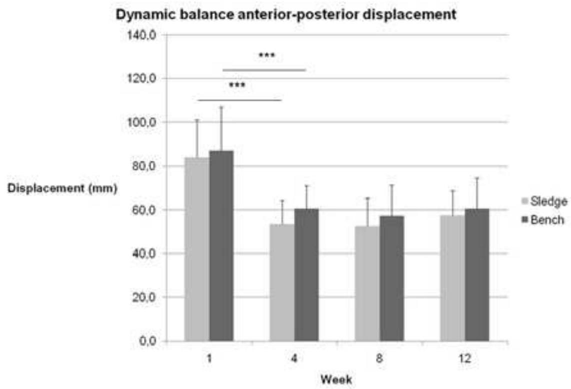

Fig.1 Anterior-posterior direction dynamic balance displacement during 12 week explosive strength training period (***$p<0.001$).

Changes in drop jump performance were almost similar in both groups. Jump height in PLY and PNE increased by 28±18% ($P<.01$) and 25±11% ($P<.05$), respectively already after the 4 weeks. Thereafter there were no more significant changes during the rest of the training period. Knee extension MVC increased in both groups but the increase was significant after 8 weeks of training

(PLY; 27±24%, p<0.05, PNE; 50±52%, p<0.05) in both groups. In knee extension 200ms RFD in PNE a significant increase was observed already after 4 week of training (37±41%, p<0.05), whereas PLY significance was observed only after the 12 weeks of training (43±73% p<0.05). Table 1 summarizes the results regarding MVC, RFD and jump height. Rest Hmax/Mmax increased slightly in PLY and decreased in PNE leading to significant (p<0.05) relative difference after the 12 weeks of training. During drop jumps, H/M20% behaved also quite similarly, although significant changes or relative differences were not observed. No significant changes were observed in passive twitch response. A significant correlation between the relative increment in H/M20% and 200 ms RFD (r=0.909, p<0.001) was observed after PLY. In all subjects (PLY+PNE; n=30), relative change in dynamic balance had a moderate but non significant negative correlation with the relative changes of the 200ms torque production (p=0.070) and with H/M20% (p=0.064) after the 12 weeks of training.

Table 1. Knee extension MVC, RFD during the first 200 ms and drop jump height during 12 week explosive strength training period. (* p<0.05, **p<0.01, ***p<0.001)

	Pre			4 week			8 week			12 week		
PLY	**MVC (Nm)**	**RFD (Nm)**	**Height (m)**	**MVC (Nm)**	**RFD (Nm)**	**Height (m)**	**MVC (Nm)**	**RFD (Nm)**	**Height (m)**	**MVC (Nm)**	**RFD (Nm)**	**Height (m)**
ave	**167**	**91**	**0,65**	**171**	**89**	**0,85 ****	**207 ***	**108**	**0,86 *****	**208 ***	**129 ***	**0,86 *****
sd	42	37	0,11	37	26	0,18	52	51	0,15	56	56	0,17
PNE												
ave	**140**	**72**	**0,63**	**160**	**97 ***	**0,77 ***	**195 *****	**119 *****	**0,79 ****	**189 ****	**117 *****	**0,75 ***
sd	44	31	0,14	42	31	0,13	32	26	0,14	34	32	0,17

DISCUSSION

These results showed that both plyometric and pneumatic explosive training can lead to significant improvements in dynamic balance control and drop jump performance already after four weeks of training. Plyometric training led to greater sensitivity in H-reflex than pneumatic suggesting stronger spinal level adaptation possibly due to changed reciprocal inhibition [4] or presynaptic inhibition [5]. A strong correlation between increased RFD and increased H-reflex response found after PLY but not after PNE indicates that neural adaptation might be different between the two different training-types. Since no changes were observed in passive twitch response a clear increase in RFD found also after PNE could possibly be more of supraspinal origin. Moderate correlations between the improved balance and increased RFD and H-reflex response suggest that while both may play a role, neither RFD or mechanisms related to H-reflex sensitivity alone can solely explain the improved balance control.

CONCLUSION

As a conclusion, different training types of the explosive strength training will lead to similar dynamic balance control adaptation. Nevertheless, the neural mechanisms beyond the adaptation might be different. In plyometric training, sensitivity of the spinal loop may be more adapted while in pneumatic training the neural drive from higher centers may be more affected.

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BALANCE EFFECTS OF TAI CHI CHUAN COMBINED WITH VIBRATION TRAINING

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INTRODUCTION

Tai Chi Chuan is a traditional Chinese art with various body movements. It is regarded as a smooth, slow, and lower strength exercise which was shown to improve the ability of balance, coordination and postural control to decrease the rate of falling in seniors[3, 6]. Although Tai Chi Chuan has so many passive effects for humans, too many moves need to be learned for a beginner and the significant training effect could only be shown after a long training period[5]. The whole-body vibration training induces muscle contraction frequency and recruits more muscle groups involved by the vibration excitation. The benefit was also observed to improve the muscle strength and the neuromuscular performance after a short term[2]. But the most posture of vibration training is always static stand or squat on the platform to accept vibration excitation, and the user is easy to feel bored and can't keep for a long time.

Therefore, the purpose of this study was to determine the effect of Tai Chi Chuan combined with vibration training in balance performance and electromyogram. We tried to combine the benefit of both methods, the various movement of Tai Chi Chuan and the acute neuromuscular excitation of vibration training, in together.

METHODS

A three group prepost design was used in this study to determine whether an 8-wks period of Tai Chi Chuan with vibration training (3 times/wk and 30 mins/time) would result in a considerable improvement in balance and neuromuscular performance. Forty-seven health, young male and female subjects (age: 20.6±1.4 yrs; height: 167.1±9.3 cm; weight: 61.8±9.4 kg) were randomly assigned to one of three interventions: the Tai Chi Chuan with vibration training (TAV, n=16), the Tai Chi Chuan (TCC, n=15), or the non-trained control group (CON, n=16). The subjects of TAV and TCC performed the same static and dynamic moves of Tai Chi Chuan, but TAV performed them on the vibration platform (32 Hz, 1 mm p-p). The 95% moving area of center of pressure was obtained as the static balance performance by forceplate, and the root-mean-square electromyogram (EMG) of quadriceps and hamstring during balance test was also obtained as the neuromuscular performance. The effect of different interventions was analyzed by means of ANOVA for repeated measures (3 groups × 2 times), and contrast analyses were performed if an overall F-value was found to be significant. Significant level was set on $\alpha = .05$.

RESULTS

For the static balance performance a significant interaction effect (group × time) was found ($F = 8.14$, $P < .01$). Contrast analysis clarified that the 95% moving area of center of pressure (Fig. 1) decreased 15.3% significantly ($P < .05$) over 8 wks in the TAV group ($F = 5.63$, $p < .01$) and increased 24.4% significantly ($P < .05$) in the CON group ($F = 13.03$, $p < .01$) whereas no significant decrease was found in the TCC group. For the neuromuscular performance a significant interaction effect (group × time) was found ($F = 3.32$, $P < .01$). Contrast analysis clarified that no significant decrease of the root-mean-square EMG of quadriceps was found in all groups ($P > .05$). The result only showed the trend of decrease in trained groups. The similar result was also found in the root-mean-square EMG of hamstring.

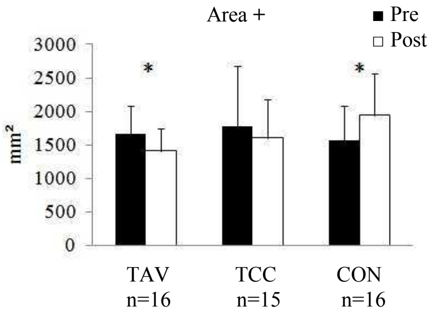

Fig.1 Mean and SD of the 95% moving area before (pre) and after (post) 8 wks in the TAV, TCC, and CON groups. + refers to a significant interaction (groups × time) effect (P< .05). * indicates that post value is significant different than pre one (p< .05).

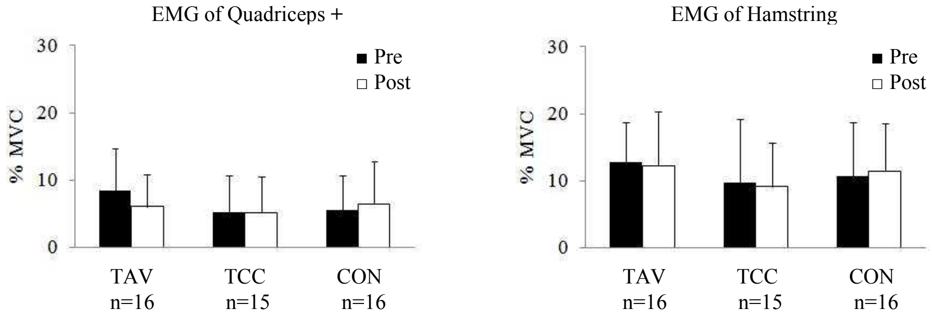

Fig.2 Mean and SD of the root-mean-square EMG before (pre) and after (post) 8 wks in the TAV, TCC, and CON groups. + refers to a significant interaction (groups × time) effect (P< .05). Left: EMG activation of quadriceps. Right: EMG activation of hamstring.

DISCUSSION

Although Tai Chi Chuan can improve the ability of balance[4], it needs to take a long training period. This study combined Tai Chi Chuan with vibration training and found the significant improvement of balance performance within 8 weeks. The pervious study determined that it could enhance the neuromuscular adaptation to make body control more stable by vibration excitation[1], and the result of this study also showed the decrease trend of EMG activation in trained groups.

CONCLUSION

From this study, we found that combining the both benefits, the various movement of Tai Chi Chuan and the acute neuromuscular excitation of vibration training, could improve the ability of balance more efficiently than Tai Chi Chuan only within 8-wks training period.

Finally, we would also like to acknowledge Magtonic Fitness Technology Inc. and Taiwan National Science Council (NSC 97-2622-B003-001-CC2) to provide the equipment and funding.

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EFFECTS OF CORE STABILITY EXERCISES ON MAXIMUM FORCE AND POSTURAL CONTROL OF THE LOWER EXTREMITY DURING 1RM SQUAT PERFORMANCE

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INTRODUCTION

In many sports a high level of maximal strength is required as a basic determinant of explosive and powerful movements. In this context the back squat is considered as a major strengthening exercise in the conditioning program of many athletes. It is hypothesized that a stable core, proberly known as the lumbopelvic hip complex (LPHC), is considered as "pivotal for efficient biomechanical function to maximize force generation". This includes the ability of the LPHC "to control the position and motion of the trunk over the pelvis to allow optimum production, transfer and control of force to the terminal segment [...] integrated kinetic chain activities" [1]. While core stability exercises do "not" target "a strength goal, strength gain do result" [2]. Instead of strength, emphazised motor control perfection due to increased muscle activation patterns around the LPHC, may result in increased levels of muscle activation in the extremities [1,2]. However, no research examined the aforementioned theses, so far.

The purpose of this study was to examine the effects of adding core stability training to leg strength training, and to compare this to a solely leg strength training on maximum strength behaviour. Further object was to examine the effects on lower extremity biomechanics, based on postural control adjustments during the execution of 1RM back squat.

METHODS

Thirty-six female athletes participated in this investigation (age 23.5 ± 3.0). According to their 1RM half back squat in a multi-power station (2 pretests 1RM were examined prior to the study to determine the approximate 1RM value), subjects were parallelized and assigned to either one of two training groups: both experimental groups performed strengthening exercises for the lower extremities (leg press, standing leg curl, and sitting calf raise) (LEG; n= 12), whereas one group performed additional core stability exercises (pillar bridge front- and side, plate crunch, side bridge, double-leg hip extension) (LEG+CS; n = 12). In addition, a control group (CG; n = 12) without any training intervention, was used for comparison. Subjects trained for 6 weeks, 3 days per weeks. Pre- and post-training 1RM values of both experimental groups and the control group were analyzed using a 3 x 2 (training program x time) repeated-measure ANOVA ($p \leq 0.05$). 1RM squatting kinematic parameters (spine-, hip-, knee- and ankle-joint-position, as well as heel- and toe- positioning) were videotaped in the sagittal plane. Videos were independently scored by 3 expert raters. The inter-rater reliability was quantified by the Kendall W coefficient of concordance ($p = 0.000$). In order to explain differences between measurements concerning the qualitative evaluation of the 1RM squat, Kruskal-Wallis repeated-measure ANOVA was used ($p \leq 0.05$).

RESULTS

Dynamic Maximum Strength. Analysis of absolute strength increases demonstrated significant differences for both experimental groups: the LEG+CS and LEG significantly increased their performances in the 1RM half back squat by 15.94 ± 10.22% ($p \leq 0.05$), and 7.46 ± 6.62% ($p \leq 0.05$), with statstically significant difference between the both groups. Both training groups showed a significant difference with the control group, which decreased performance by -3.28 ± 5.49% ($p \leq 0.05$).

Tab.1 Pre- and post-test means (±SD) of 1RM back squat (kg);

training group	n	mean ± SD pretest	mean ± S± SD posttest	percentaged change ± SD
LEG+CS	12	104.8 ± 21.34	120.6 ± 19.1	15.94 ± 10.22
LEG	12	100.8 ± 20.87	108.0 ± 22.7	7.46 ± 6.62
CG	12	104.8 ± 17.0	101.9 ± 17.3	-3.28 ± 5.49

Video analysis. The inter-rater reliability, expressed as Kendall´s W, was 0.703 ($p = 0.000$). The three groups analyzed by Kruskal-Wallis showed no significant differences between the compared squatting patterns in the pre- and post-evaluation, χ^2 (2) = 0.217 ($p \leq 0.05$).

DISCUSSION

The results of the present study indicate distinct superiority of a leg strength training program combined with additional core exercises over a separate leg strength program in terms of improved adaptations in dynamic strength development of the lower extremities. This seems to make sense, if the LPHC is considered to be the limiting factor of 1RM back squat performance. Additional strength gains within the combined training group (LEG+CS) support the assumption, that the selected stabilization exercises determined specific adaptions within the aforementioned area. Increased stability/stiffness of the LPHC due to improved synergistic control mechanisms (co-contraction) seems to provide greater force development of the lower extremities during the execution of dynamic movements. The evaluation of the external squatting pattern did not show any changes in execution quality under maximal loading conditions (1RM). Two reasons may be responsible for this observation: 1) the chosen time frame of 6 weeks with a training frequency of 3 sessions per weeks possibly has been not long enough to induce changes in the 1RM squat execution quality 2) with a non-specific training approach (leg training using machines/horizontal trunk exercises versus multipower-station-based 1RM-squat testing) changes in 1RM execution quality are difficult to induce.

CONCLUSION

The present study supports the importance of integrating core stability exercises into athletes conditioning programmes to enhance trunk function as well as lower extremity function/strength development.

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CHANGES IN SPEED AND STRENGTH IN FEMALE JUNIOR VOLLEYBALL PLAYERS AFTER A PLYOMETRIC TRAINING PROGRAM

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INTRODUCTION

In volleyball the achieved level of explosive power is an essential part of most player skills. It enables players' activities during the game not only in a required height and with the necessary power but also at the right moment. The plyometric method is ranked among the most frequently used methods for conditioning including volleyball [4, 10, 11, 12]. The topic of using the plyometric method in athletes' preparation, volleyball players included, has been the centre of attention for many authors [1, 2, 3, 6, 9, 13]. A plyometric training program should consider the goal of the training for a particular period, should respect basic training principles, first of all the principle of individualization, the principle of progressively increasing load, the principle of specificity [4, 5, 8]. The aim of this study is to verify what changes in the explosive power and the speed will come after an eight-week plyometric training program in female junior volleyball players.

METHODS

The plyometric training program was applied during an 8-week period to a group of female youth volleyball players (n = 11; average age 14, 8 ± 0, 9; height 169 ± 6 cm; weight = 58 ± 9 kg). The exercises were practiced twice a week, the number of sets was 2-4 (8-10 repetitions in a set) and a rest interval between sets was 90 seconds. The training program was divided into three cycles lasting 2, 4 and 2 weeks. Actual level of the take off power and speed was evaluated by standing vertical jump, vertical jump with approach (spike jump) and shuttle run for 6 x 6m. To diagnose changes in the chosen parameters during the monitored period players were tested before the start of the program and the sixth week after completion of the program.

RESULTS

The comparison of the test results shows that the players scored better in post measurements in both the test of standing vertical jump and in the test of vertical jump with approach (improvement in the height was about 4cm and 4.9cm, respectively). The both results are statistically significant (Tab. 1). The greater improvement in the vertical jump with approach could be caused by the higher similarity of the plyometric movement exercises and plyometric tests. The results of the monitoring are similar to our previous study [7], which was made by volleyball players in the same age category (improvement after the 8-week plyometric training program 2.6cm and 4.4cm, respectively). The reasons for the greater improvement by the present group can be different. We consider that the positive factor could be three-month strength preparation, which was done before the plyometric program. Also, logically and statistically significant improvements of average values in the test shuttle run for 6 x 6m by 0.7s coincide with the knowledge that plyometric exercises can stimulate athletes' speed. We didn't expect so strong an improvement because the similar progress in the dynamic speed changes during the ontogenetic improvement is typical for the longer time period [15, 16].

Tab. 1 Statistical significance of test scores – pre- and post measurements

Parameter	M	Med	d	Z
SVJ1	9.50	9.50	.04	**.41***
SVJ2	3.54	4.00		
VJA1	8.33	9.50	.96	**.41***
VJA2	3.27	5.00		
SR1	1.08	0.90	.30	**.01***
SR2	0.38	0.20		

Legend: SVJ – standing vertical jump (cm); VJA – vertical jump with approach (cm); SR – shuttle run for 6 x 6m (s); 1 – pre measurements; 2 – post measurements M – Average; Med – Median; d – difference; Z – value of statistical criterion (Sign-test); * $p<0.05$.

CONCLUSION

We found logically and statistically significant improvements of the explosive power tested by the tests standing vertical jump and vertical jump with approach after the eight-week training. The results of the study support the opinion, that plyometric exercises can be an effective tool for improvement of the explosive power and speed of youth athletes.

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EFFECTS OF WHOLE-BODY VIBRATION VS. CONVENTIONAL SQUAT EXERCISE ON ELECTROMYOGRAPHIC RESPONSES AND RATE OF PERCEIVED EXERTION

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INTRODUCTION

Recently, there has been a growing interest in the training effects of squat exercise executed on a vibrating platform. Research findings indicate that squat exercises, performed on a vibrating platform, increase the strength of the leg extensors to a similar extent as can be realized by means of conventional resistance exercise at moderate intensity [2]. However, to develop a structured training methodology by means of progressive loading through vibrating platform, we need to understand how the magnitude of acceleration ($m{\cdot}s^{-2}$) impacts on muscle activation and to compare this with the training stimulus of squat exercise through traditional loading (kg). To the best of our knowledge, no study has compared neuromuscular effect of vibration exercise versus conventional resistance exercise at different loads. Thus, the aim of this study was to investigate muscle activation and rate of perceived exertion (RPE) during semi-squat exercise on vertical vibration platform compared with semi-squat exercise performed on a Smith machine.

METHODS

Twenty three recreationally active students (15 males and 8 females; age = 24.3 ± 2.3 years, height = 174.5 ± 8.3 cm, mass = 69.9 ± 8.1 kg) participated. Subjects were exposed to 6 different loads in one of both exercise modes: vibration platform (Fitvibe, GymnaUniphy NV, Bilzen, Belgium) or Smith machine (Nautilus NT 1800; Nautilus, Inc., Vancouver, WA, USA). The subject performed a squat in 6 experimental conditions; the load differed per experimental condition. For each subject the exercise mode (n=2) and the different loads per mode (n=6) were assigned in a random order to check the influence of vibration magnitude (acceleration: from 12.5 to 88.4 $m{\cdot}s^{-2}$) as well as weight (from 20 to 70 kg) on sEMG (vastus medialis [VM], vastus lateralis [VL], biceps femoris [BF], medial gastrocnemius [MG], and lumbar paravertebral [LP]) muscles were measured using and RPE. Each experimental condition lasted 15s, with 60s of rest between each condition.

RESULTS

For RPE, lumbar and lower body sEMG revealed a significant weight main effect ($p < 0.01$) and a significant acceleration main effect ($p < 0.01$). A strong positive relationship was elicited between the training load (weight or acceleration) on the one hand and the muscle activation (lumbar sEMG, lower body sEMG) and RPE on the other hand ($p \leq 0.01$). All correlation coefficients were higher than 0.70.

TABLE 1. Rating of perceived exertion (RPE) and surface electromyography (sEMG) activity at each experimental condition. * $p < 0.01$ significantly different for 20kg weight exercise or 12.5 m·s^{-2} vibration exercise. # $p < 0.01$ significantly different for 30kg weight exercise or 20.2 m·s^{-2} vibration exercise. & $p < 0.01$ significantly different for 40kg weight exercise or 30.9 m·s^{-2} vibration exercise. ¶ $p < 0.01$ significantly different for 50kg weight exercise or 36.3 m·s^{-2} vibration exercise.

	RPE	Increment of lumbar sEMG (%)	Increment of lower body sEMG (%)
	Mean SD	Mean SD	Mean SD
Weight (kg)			
20	1.5 ± 0.8	24.1 ± 87.7	41.3 ±35.2
30	2.7 ± 1.1*	64.1 ± 96.9	63.0 ± 39.5
40	4.0 ± 1.7*	101.8 ± 96.1	78.0 ±42.0
50	4.8 ± 2.1*#	168.4 ± 209.4	108.8 ± 55.9*#
60	5.3 ± 2.2*#	189.9 ± 264.4*	157.3 ± 74.0*#&¶
70	6.2 ± 2.3*#&	283.4 ± 202.1*#&	166.9 ± 52.8*#&¶
Acceleration (m·s^{-2})			
12.5	1.5 ± 1.1	18.0 ± 26.3	60.7 ± 62.4
20.2	2.4 ± 1.6*	28.5 ± 33.6	51.8 ± 28.5
30.9	3.3 ± 1.8*	33.1 ± 36.4	63.4 ± 49.4
36.3	3.8 ± 1.6*#	53.5 ± 54.5	138.3 ± 82.6*#&
60.1	5.5 ± 1.9*#&¶	83.8 ± 65.4*#&	175.3 ± 72.1*#&
88.4	6.4 ± 1.9*#&¶	71.5 ± 61.3*	161.5 ± 68.6*#&¶

DISCUSSION

To the best of our knowledge, this is the first study that analyzed muscle activation and rate of perceived exertion during squat exercise on vibration platform (acceleration; m·s^{-2}) compared with Smith machine (weight; kg). The primary finding of the present study is that an increase of acceleration by 1 m·s^{-2} applied by the vibration platform results in increases of lower body sEMG (mean sEMG of VM, VL, BF and MG) of 0.42%, and 1kg of additional weight on the Smith machine increases lower body sEMG on average by 0.36%. This means that in this group of recreationally active students the lower body sEMG during a semi-squat on a vibration platform with an acceleration of 60 m·s^{-2} almost equals the lower body sEMG during a semi-squat on a Smith machine with 70 kg load. A direct relationship between the intensity of exercise by weights and the percentage of maximal sEMG has been previously established [1].

CONCLUSION

The results from this study demonstrate that in young, recreationally active, adults the training stimulus resulting from an isometric semi-squat exercise on a vibration platform (acceleration: from 12 to 89 m·s^{-2}) is similar to the training stimulus of an isometric semi-squat exercise on Smith machine (weight: from 20 to 70 kg) according to lower body sEMG and RPE. However, the impact of semi-squat on vibration platform exercise for lumbar muscle is relatively small compared with semi-squat on Smith machine.

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Saturday 11:00-12:30

Oral Podium Presentations II.

EFFECTS OF PASSIVE LEG PRESS TRAINING ON JUMPING PERFORMANCE SPEED AND MUSCLE STRENGTH

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INTRODUCTION

Sports science experts and scholars are trying to develop new ways of training muscles. Not only the strong urge of scientific eagerness but a massive demand of athletes for discovering more modern and effective methods of boosting muscle strength gave our team the motivation to initiate the present research. The Passive Leg Press training machine, PLP training machine, was developed based on the concepts of Stretch-Shortening-Cycle and benefits of high muscle contraction velocity [1]. During the PLP training subjects' shoulders were restricted from an upward vertical motion by a stationary cushioned bar. It enabled muscle groups of the lower limbs to apply a maximum downward force against the moving platform. Therefore the study intended to investigate effects of a 10 week long Passive Leg Press (PLP) training on triple long jump, vertical jump, 30m sprint and isometric muscle strength.

METHODS

Thirty healthy participants with no regular experience in muscle training and without record of any injury have been selected from the Department of Physical Education, Hualian Normal College in Taiwan. Participants randomized into three groups (n=10) traditional muscle training group and the low/high frequency PLP training groups. The intervention had been concluded for 10 weeks with three muscle trainings of the same intensity per week. The training protocols of groups were showed in Table 1. The triple long jump, vertical jump, 30m sprint and isometric muscle strength were measured under the same experimental procedures at pre-training (0 weeks), mid-training (5 weeks), and post-training (10 weeks).

Table 1. Training protocol of three groups.

parameters	Traditional	PLP-low	PLP-high
Equipment	Smith Press	PLP machine	PLP machine
Training type	Isotonic	PLP	PLP
Frequency	0.5 Hz	0.5 Hz	2.5 Hz
Load	70% of 1RM	70% of 1RM	70% of 1RM
Time	20 sec	20 sec	20 sec
Sets	5	5	5
Interval time	2 mins	2 mins	2 mins
Time per week	3	3	3
Duration	10 weeks	10 weeks	10 weeks

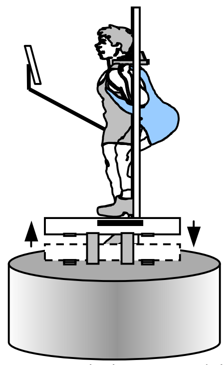

Fig.1. PLP training machine

1. Traditional muscle training group: The Cybex Smith Press CB-5341 training machine was applied as the training equipment for this group at the controlled movement frequency of 0.5 Hz. Participants actively finished one complete cycle of movement in each 2 seconds.

2. Low/High frequency PLP training groups: The PLP muscle-training machine, as shown in Fig.1, was applied as the training equipment for the low/high frequency PLP training group at the controlled movement frequency of 0.5 Hz and 2.5 Hz respectively. Apart from the difference between the training method of these groups and the traditional muscle-training group (PLP vs.

Isotonic), the rest of training parameters were the same. The low and high frequency group differed in frequency, but they had identical training parameters.

RESULTS

After a five-week high frequency PLP training the triple long jump, vertical jump, 30m sprint performances have slightly decreased. It might be the result of the high intensity of high frequency PLP training. Due to this training all muscles became fatigue and the above performances decreased. However between the fifth and tenth week of the same training, each performance has significantly improved ($p<.05$). The traditional muscle training and high frequency PLP training both significantly increased isometric muscle strength ($p<.05$). In addition to these results showed that high frequency PLP training trended to develop vertical jump and 30m sprint significantly better than the traditional muscle training did ($p<.05$).

DISCUSSION

With the application of high frequency PLP training the triple long jump, vertical jump, 30m sprint performances can all be significantly improved. One of PLP training characteristics was that subjects contracted their muscle groups of lower extremities faster than at voluntary contraction, because the platform of PLP training machine was driven by an electrical motor [1]. Previous studies found that PLP training recruited more motor units in target muscle due to higher IEMG [2]. The 10-weeks of PLP training at movement frequency of 2.5 Hz showed a 4~5% increase of cytoplasmic hsp72 protein contents and the mRNA expression got several times higher. Furthermore, the high frequency PLP training has indicated an increase in the ratio of type I muscle fiber and type II muscle fiber from 80.62% to 81.38% and from 77.78% to 82.77% in two subjects [3]. The neuromuscular function of high frequency PLP training was a major contribution to the enhancement of jump performance, sprint speed and muscle strength.

CONCLUSION

PLP training with the PLP muscle-training machine powered by an electrical motor enabled muscle groups of lower extremities to contract faster than at voluntary contraction. The current study found significant improvement on triple long jump, vertical jump, 30m sprint and isometric muscle strength after a 10-week long PLP training. Athletes who take part in intense competitions need to build up their muscle strength and power in order to deliver extraordinary performance. PLP training is an entirely new way of enhancing muscular fitness and it might emerge to be a major training choice for athletes in the future.

Acknowledgement: This research, *NSC 94-2413-H-028-005*, was financially supported by National Science Council, Taiwan, ROC.

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THE EFFECT OF STRENGTH TRAINING AND TESTOSTERONE GEL ON MUSCLE STRENGTH AND POWER, IN MEN AGED 60-78 WITH LOW TESTOSTERONE LEVELS

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INTRODUCTION

Hypogonadism is defined as a testosterone level below the normal range for men and is associated with reduced muscle mass, reduced muscle strength and general impairment of physical function [1]. It is well known that testosterone plays a critical role in the formation, maintenance, and regeneration of skeletal muscles [2, 3]. Therefore, testosterone is used as an anabolic therapy in the treatment of hypogonadism [4]. However the effects of testosterone therapy on functional performance is less studied and there is a lack of knowledge concerning how testosterone therapy improves performance related measures i.e. muscle strength, muscle power, jump height etc. Most studies on testosterone therapy reveal anabolic effects that are modest compared to what can be achieved by strength training [5]. It appears that increases in muscle strength by testosterone therapy are possible without training in younger men [6], but this seems not to be possible to a significant degree in older persons [7, 8].

The aim of this study was to investigate the use of strength training as an alternative to testosterone therapy and as a supportive intervention in conjunction with testosterone therapy. Therefore we investigated the effect testosterone gel (Testim®), the effect of strength training and the effect of strength training combined with testosterone gel on muscle strength and muscle power, in a randomized, placebo-controlled and double-blinded study including men aged 60-78 with a bio available testosterone < 7.3 nmol/L and a waist circumference > 94 cm.

METHODS

Participants: The inclusion criteria were age 60-78 years, bioavailable testosterone levels < 7.3 nmol/l and a waist circumference > 94 cm. The exclusion criteria were hematocrit > 50 %, prostate cancer or a prostate specific antigen (PSA) > 3 ng/dl, previous or ongoing malignant disease, severe ischemic heart or respiratory disease, disability, diabetes mellitus, alcohol or drug abuse, abnormal routine blood samples (TSH, ionized calcium, hemoglobin, liver and kidney function) and treatment with 5α reductase inhibitors, morphine or oral glucocorticoid steroids. Participants were randomized to testosterone gel, placebo or strength training for 24 weeks. In the testim group (n=20) and placebo group (n=18) participants initially received 50-100 mg testosterone or placebo, respectively. The strength training group (n=16) completed 12 weeks of strength training, followed by 12 additional weeks of strength training, were the subjects were randomized into either testim (n=6) or placebo (n=9) (Figure 1).

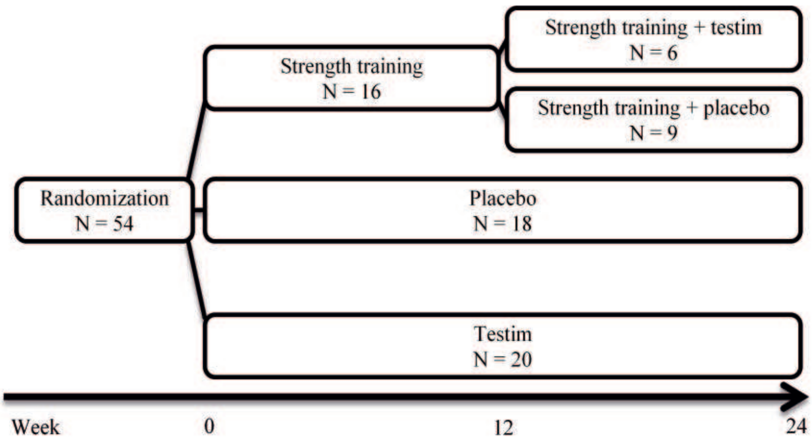

Figure 1. Overview of the study design.

Strength training: Participants carried out a periodized strength training program including exercises for the entire body. Familiarization was carried out during the initial four weeks with low resistance (10-20 Repetition Maximum, RM) and volume. Hereafter participants performed 6 - 10 reps with corresponding 6 - 10 RM loads x 2 - 3 sets per exercise, 3/wk. All training sessions were supervised in order to control the training techniques, training loads, and training log books.

Performance testing: Participants were tested before, midways (after 12 weeks) and after 24 weeks of intervention. Test comprised counter movement jump (CMJ) and isometric maximal voluntary contraction (MVC). All subjects performed five maximal CMJ on a force platform (Kistler 9281 B, Switzerland) and CMJ trials were analyzed for maximal vertical jump height. The MVC protocol implicated isometric knee extensions of the left leg in a KinCom dynamometer (KinCom 500H, software version 4.03, Chattecx Corp., USA). All subjects had five trials which were analyzed for peak torque and peak rate of force development (ΔM/ΔT, RFD).

Statistics: Differences between groups were evaluated by two-way ANOVA repeated measures. A significance level of P≤0.05 was chosen and data are presented as means± SEM.

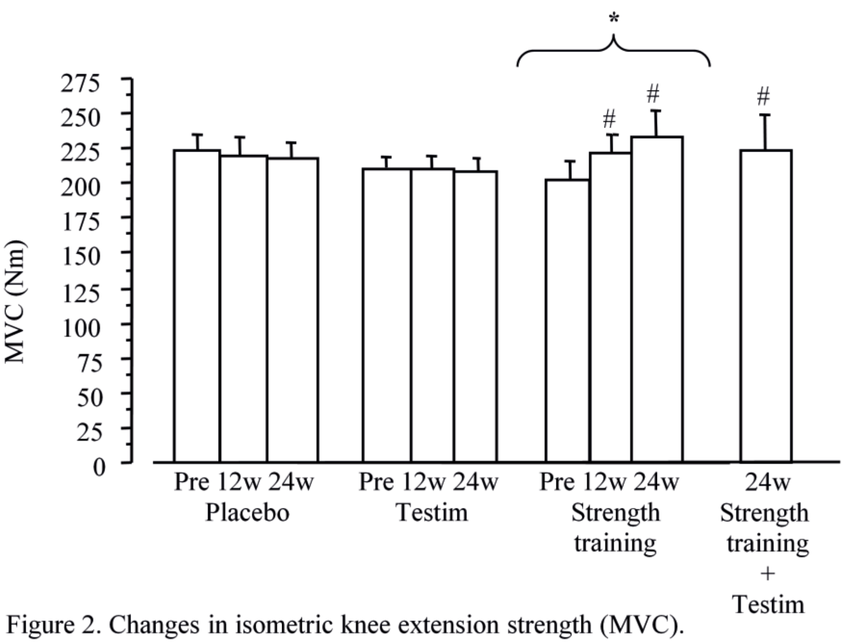

Figure 2. Changes in isometric knee extension strength (MVC).
Placebo group n=18, Testim group n=20, Strength training group n=9,
Strength training + testim group n=6.
* Significant increase over time compared to placebo and testim groups (P < 0.01)
# Different from previous timepoint in strength training group (P < 0.01)

RESULTS

The strength training group increased MVC and RFD (data not shown) significantly and in the same manner during the intervention period, whereas no changes were seen in jump height (data not shown). There was no additional effect seen by adding testim to strength training (Figure 2). The placebo group and the testim group, showed no changes in above mentioned measures.

CONCLUSIONS

- Testosterone gel alone did not affect performance in terms of muscle strength and muscle power measured as MVC, RFD and jump height over a 24 week intervention period in men aged 60-78 with low normal bio available testosterone levels.
- Strength training alone increased MVC and RFD but not jump height.
- No additional effect were seen when strength training were combined with testosterone gel.

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RESISTANCE EXERCISE TRAINING AND CHANGES IN TESTOSTERONE PRODUCTION AND CLEARANCE RATE IN YOUNGER AND OLDER MEN

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INTRODUCTION

Serum testosterone (T) concentration is maintained at appropriate level by the balanced processes of metabolic clearance rate (MCR_T) and production rate of T (PR_T). During a typcal heavy resistance exercise session, serum T concentration has been shown to increase gradually reaching the highest values at the end of the exercise [1]. Heavy resistance exercise-induced acute responses in serum T concentration as well as changes in basal T following long-term resistance training may be caused either by the changes in PR_T or by changes in MCR_T, or both. Previous studies have shown that constant infusion of stable isotope-labeled T, and using the liquid or gas chromatography system connected with a tandem mass spectrometry for analyses, allows valid measurements of MCR_T and PR_T after the physiological interventions [8,9]. The role of MCR_T or PR_T to acute or chronic heavy resistance exercise training-induced T responses is, however, not previously studied.

We hypothesized that heavy resistance exercise bout have an acute effect on MCR_T and/or PR_T and, furthermore, the basal rates as well as the exercise-induced effects on MCR_T and PR_T are attenuated in older compared to younger men. Moreover, we hypothesized that stimulation of T metabolism by the regular resistance exercises during the long-term resistance training induce changes in T turnover rate. Therefore, the purpose of the present study was to examine acute resistance exercise-induced changes in MCR_T and PR_T, and their possible adaptations to long-term resistance training in younger and older men.

METHODS

The intervention group consisted of healthy untrained young adult (YM, $n = 5$; 28 ± 3 yrs, 183 ± 7 cm, 93 ± 9 kg, 22 ± 3 fat%) and older men volunteers (OM, $n = 8$; 70 ± 2 yrs, 177 ± 6 cm, 79 ± 8 kg, 23 ± 2 fat%) who participated in a 12-month supervised progressive whole body resistance training (RT) program including training sessions two times a week at months 1-6 and three times per week, with upper and lower body training sessions in turn, at months 7-12. Maximal muscle strength (1RM) of leg extensors and cross-sectional area (CSA) of m.vastus lateralis (VL) were measured pre- and post-RT. Experimental heavy resistance exercise (HRE) sessions (5 x 10RM leg presses, 2min recovery between the sets) were performed pre- and post-RT. T isotope 1,2-D2 (D_2T) was infused (0.0005 mg/ml) constantly over the 10.5 h period between 6AM and 4:30PM at approximately 42 ml/h. After an equilibration period of 6 h, blood samples were drawn every 15 min for 2 h before and after HRE as well as after the third set of the leg presses to determinate serum LH concentrations. Blood samples were pooled for MCR_T and PR_T analyses as follows; Pre-sample (30-0 min pre-exercise), Post0-sample (after the third set of the leg presses and 0 min post-exercise), and Post1h-sample (30-60 min post-exercise). Analysis for unlabeled T (D_0T) and D_2T were performed by the liquid chromatography system connected with a tandem mass spectrometry. MCR_T was calculated by the formula: MCR_T = amount of D_2T infused per hour divided by concentration of D_2T in the serum and multiplied by 24 h to express as liters per day (per body surface area as liters per day per meter^2). PR_T was then calculated from the formula: $PR_T = MCR_T$ multiplied by serum D_0T concentration, expressed in milligrams per day per meter^2 [9]. HRE-induced plasma volume (PV) shifts were calculated by blood Hb and Hct values [3]. Because no statistically significant differences were observed in HRE-induced PV shifts between the groups or between the pre- to post-RT values, the present circulating hormone concentrations are presented as uncorrected to PV changes.

RESULTS

1RM of leg extensors and CSA of VL increased following RT in both groups. HRE-induced changes in serum T concentrations did not reach statistical significance within or between the groups before or following the RT, although highly individual HRE-induced responses in T were observed. No statistically significant differences or changes were observed in LH concentrations before or following the RT within or between the groups. No statistically significant differences or changes were observed in MCR_T and PR_T during HREs within or between the groups before or following the RT, except of decrease in MCR_T from Post0 to Post1h ($p<0.05$) in YM after the RT. When the groups were combined, MCR_T decreased from Post0 (474 ± 58 l/m^2/d) to Post1h (394 ± 34 l/m^2/d, $p<0.05$) and PR_T increased from Pre (1.5 ± 0.1 mg/m^2/d) to Post0 (1.7 ± 0.2 mg/m^2/d, $p<0.05$) and decreased from Post0 to Post1h (1.4 ± 0.1 mg/m^2/d, $p<0.01$) after the RT. In the combined group of YM and OM, the relative changes from Pre to Post0 in serum T and MCR_T correlated between each other ($r = -0.70$, $p < 0.01$) after RT.

DISCUSSION

In men, T production is regulated by the function of the hypothalamic–pituitary–testicular axis. Also during and after the exercise, changes in T synthesis rate, and consequent changes in serum T concentrations, could be caused by the changes in LH pulsatility or production [7]. In the present study, however, no HRE- or RT-induced changes were observed in serum LH concentrations and it was not related to changes in MCR_T and PR_T observed. This finding indicates that LH independent factors may explain individual exercise-induced changes in serum T concentrations. The main site of T metabolism is the liver where T undergoes enzymatic conversions to metabolites that are eliminated by the kidney. The study by Cadoux-Hudson et al. [2] using a continuous infusion of 3H-testosterone suggested that endurance exercise-induced elevation in serum T was due to the reduction in the rate at which T is cleared from the plasma and that, as suggested by them, is caused principally by the concurrent reduction in hepatic plasma flow. Effect of heavy resistance exercise on hepatic blood flow is not known, but incremental endurance exercise to exhaustion has shown to induce two-third reduction in hepatic blood flow [5] that could be mediated by increased sympathetic nervous activity during exercise [6]. An acute bout of resistance exercise has been shown to increase plasma concentrations of catecholamine’s [4] and, thus, it could be assumed that also heavy resistance exercise induce reductions in hepatic blood flow which, consequently, increase serum T concentration by decreases in MCR_T. This assumption is supported in the present study due to the negative relationship observed between the relative changes in serum T and MCR_T at Post0 after RT in the combined group of YM and OM.

CONCLUSION

The results of the present study suggest that heavy resistance exercise-induced changes in serum T concentrations are primarily related to the exercise-induced changes in MCR_T, which is possible caused by changes in hepatic blood flow.

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COMPARISON OF CARDIOPULMONARY RESPONSES TO DYNAMIC AND ISODYNAMIC EXERCISE TESTS IN STRENGTH AND ENDURANCE ATHLETES

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INTRODUCTION

Aerobic endurance training differs from resistance strength activities with respect to cardiovascular system adaptation to physiological stress [1]. The acute dynamic exercise performed with a large muscle mass such as in running causes a substantial increase in oxygen consumption (VO_2), cardiac output, heart rate (HR), stroke volume, and systolic blood pressure (SPB); a moderate increase in mean arterial blood pressure (MABP), and a decrease in diastolic blood pressure (DBP) and total peripheral resistance (TPR) [2-4]. In contrast, static isometric exercise such as heavy resistance training promotes a small increase in VO_2, and cardiac output and marked increases in HR, TPR, SBP, DBP and MABP [5-7]. However, the cardiopulmonary responses of strength versus endurance athletes in dynamic and isodynamic exercise tests are not known. Therefore, the aim of the study was to investigate possible differentiations in cardiopulmonary responses to dynamic and isodynamic exercise tests in strength versus endurance athletes.

METHODS

Twenty- eight male recreation athletes volunteered to participate in this study and were classified into: endurance group, (runners n = 17, age 29.47 ± 6.79 yr and 11.09± 5.01 training yr) and strength group, (body builders, n =11, age 25.82 ± 3.97 yr and 8.14 ± 4.34 training yr). Two cardiopulmonary exercise tests (CPET) were performed using breath-by-breath analysis, (Sensor Medics Vmax-229 CA, USA) in randomized order, using standard Bruce treadmill protocol; one of which was performed with hand-held weights (20% of each subject's body weight) (isodynamic), and the other without weights (dynamic).

RESULTS

Conditions	Dynamic		Isodynamic		P(ANOVA)		
Parameter\ group	**Strength n=11**	**Endurance n=17**	**Strength n=11**	**Endurance n=17**	**Within**	**Between**	**Interaction**
VO_2 Peak (ml*kg*min-^{1})	45.9±4.99*†	63.62±7.43*†	43.71±7.34*†	59.62±6.41*†	0.004	0	0.655
AT (ml O_2*kg*min-1)	28.45 ± 4.93*†‡	41.95±7.42*†‡	28.28 ±4.15*†‡	34.24 ±4.87*†‡	0.01	0	0.013
AT % VO_2 Peak (%)	62.25±10.16‡	66.94±8.42‡	65.37± 8.1‡	58.05±10.17‡	0.24	0.658	0.02
HR Peak (beat*min-^{1})	184.6 ± 11.96*	182.12±7.21*	182.6±11.02*	176.27±7.31*	0.001	0.201	0.117
Peak SBP (mmHg)	161.25±6.41*	155.36±13.65*	172.86±16.04*	168.33±14.03*	0.004	0.342	0.841
Peak DBP (mmHg)	79.38±9.43*†	66.43±9.29*†	98.57±6.9*†	82.08±11.17*†	0	0.001	0.554
MABP (mmHg)	106.67±6.67*†	96.07±8.26*†	123.33±9.03*†	110.83±10.83*†	0	0.002	0.732
RPP (mmHg * beat*min-^{1})	29721±2339.82†	28256.79±2403.63†	31990±3263.7†	29572.5±2951.44†	0.057	0.037	0.94
Peak VE (L*min-^{1})	143.8±11.05*	147.69±15.84*	137.31±10.92*	138.64±12.51*	0	0.7	0.671
Test Duration Time (min)	8.85± 1.23*†‡	12.87± 1.46*†‡	6.7± 0.98*†‡	9.37± 1.06*†‡	0	0	0

Table 1 Cardiopulmonary parameters in dynamic and isodynamic exercise tests among strength and enduranse athletes. * Significantly different within the conditions. †Significantly different between the groups. ‡Interaction. VO_2 Peak = peak oxygen consumption; AT = anaerobic threshold; HR = heart rate; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; MABP = mean arterial blood pressure; RPP = Rate Pressure Product; VE = minute ventilation.

The endurance athletes decreased their anaerobic threshold (AT) and AT%VO_2 peak during isodynamic exercise, while strength athletes showed similar values during dynamic and isodynamic conditions. Furthermore, both groups presented shorter test duration time (TDT) in isodynamic condition, but endurance athletes showed larger decline in TDT. In addition, peak VO_2, HR and minute ventilation (VE) were significantly lower during the isodynamic exercise test in both groups of athletes. In contrast, peak SBP, DBP and MABP were significantly higher during isodynamic exercise. Endurance athletes demonstrated higher peak VO_2 and lower peak DBP, MABP and rate pressure product (RPP) in all conditions of the study.

DISCUSSION

The present work has shown that AT, AT%VO_2 peak and TDT were significantly different between the groups and exercise conditions. This interesting phenomenon is probably related to the high physiological stress that occurs in the early stages of the exercise test provoked by the isometric component of weight carrying. This stimulus is not common to endurance athletes who are not exposed to this component in their chronic training. It was also demonstrated that both endurance and strength athletes manifested lower peak VO_2, HR and VE. This evidence supports the hypothesis that the isometric component of weight bearing that was added to the dynamic activity on treadmill results in early local fatigue and lack of full utilization of central physiological systems by lowering their responses. In contrast, peak systolic, diastolic, and mean arterial blood pressure responses were significantly higher during the isodynamic condition in both groups of athletes, which is comparable with previous studies and supported by Sagiv et al. [8-9] and Auble et al. [10]. Endurance athletes showed higher values of peak VO_2 in both dynamic and isodynamic exercises compared to strength athletes. In addition, peak diastolic, MABP and RPP were significantly higher in strength group in all conditions of the study, which corresponded with previous works [11-12].

CONCLUSION

Strength and endurance athletes had different cardiopulmonary responses to dynamic and isodynamic exercise tests. These differences are presumably related to the nature of specific, chronic adaptations to training in those athletes.

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STRENGTH DEFICIT CHARACTERISTICS IN ISOMETRIC AND STRETCH-SHORTENING TASKS FOLLOWING A SINGLE BOUT OF DAMAGING EXERCISE

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INTRODUCTION

In studies investigating exercise induced muscle damage (EIMD) symptoms, time course, and proposed mechanisms for strength loss and recovery are well documented [1]. The type of tasks used for determining voluntary strength deficit is however rarely taken into consideration. Mostly isometric strength is used as measure to quantify EIMD. In sports movements, however, these types of contraction rarely exist, and much less information is available how EIMD affects strength during stretch-shortening cycle (SSC) contractions. Previous studies used multi-joint SSC exercise tests such as VJ [2], DJ [2] or sprints [3] to investigate the effects of EIMD on muscle function, however results are contradicting. Furthermore it is unknown how EIMD affects strength loss when different load is used in SSC exercise tests. In our laboratory we examined the acute effects of EIMD on muscle function during isolated, single joint SSC and isometric contractions. Specifically we tested the hypothesis that 1. after EIMD the magnitude of torque deficit depends on the type of contraction, and that 2. magnitude of torque and mechanical efficiency deficit in SSC contractions are different when stretching energy is manipulated.

METHODS

On Multicont II dynamometer nine previously trained males (age = 23,8 ± 4,6 years) performed 90 maximal isokinetic eccentric-concentric contractions with the right knee extensors at $60° \cdot s^{-1}$ between 20 to 80° of range of motion. Plasma CK activity, delayed onset muscle soreness (DOMS), maximal voluntary isometric torque (MIC), and torque at two peaks in the eccentric phase of the SSC contraction (MSC1, MSC2) performed with three stretching conditions (120, 150 and 180 Joule of stretching energy) were determined before and 24h post-exercise. During SSC contraction angular displacement ($\Delta\varphi$) in knee joint, positive and negative mechanical work (Wn, Wp) and efficiency (η) of the quadriceps femoris were also calculated.

RESULTS

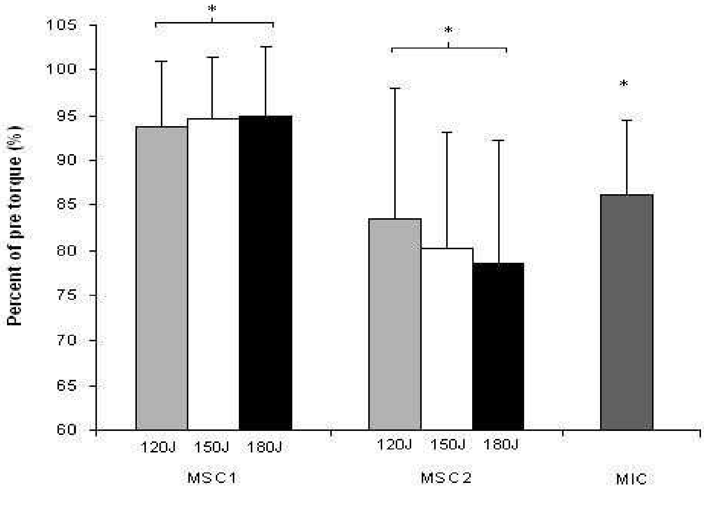

Figure. Changes in torque of the knee extensor muscle 24h after damaging exercise, measured in the eccentric phase of stretch shortening cycle (SSC) test (with three stretching conditions: 120J, 150J, 180J) and in isometric test. Values are expressed as percentage of pre-exercise torque (mean ± SD).
* *Significantly different from pre-exercise (p<0.05)*

MIC, and both MSC1 and MSC2 decreased in all three stretching conditions 24h post-exercise (Figure) ($p<0.05$). Changes in $MSC1_{150}$ and $MSC1_{180}$ were significantly smaller than in $MSC2_{150}$ and $MSC2_{180}$ respectively ($p<0.05$). Change in $MSC1_{120}$ and $MSC2_{120}$ did not differ. Changes in $MSC1_{150}$ and $MSC1_{180}$ were significantly smaller than in MIC ($p<0.05$). Manipulation of stretching energy did not affect changes in any MSC1. Though higher stretching energy resulted in higher mean of percent change in MSC2, these changes were not significantly different. From pre to 24h post exercise Wn increased in all stretching conditions ($p<0.05$), while Wp did not change, though Wp180 just missed the level of significance ($p=0{,}062$) (Table). η did not change with time in the 120J and 150J stretching conditions, but decreased significantly in the 180J condition ($p<0.05$) (Table). From pre to 24h post $\Delta\varphi_{120}$ did not change, but $\Delta\varphi_{150}$ and $\Delta\varphi_{180}$ decreased significantly ($p<0.05$).

Table. Angular displacement ($\Delta\varphi$), negative and positive work (Wn, Wp), and mechanical efficiency (η) measured before and after the damaging exercise. * *Significantly different from pre-exercise value (p<0.05)*

Stretching condition	120J		150J		180J	
	Pre	24h post	Pre	24h post	Pre	24h post
Δφ (degree)	44,1(±7,4)	48,7(±5,1)	53,5 (±4,8)	58,7(±5,5)*	59,0(±4,5)	66,4(±6,9)*
Wn (J)	116,6(±2,1)	119(±2,2)*	148,5(±2,6)	150,6(±2,7)*	179,6(±3,3)	181,8(±3,3)*
Wp (J)	107,3(±24,9)	108,5(±16,9)	138,8(±26)	126,3(±16,5)	147,3(±18,7)	134,5(±10,2)
η (%)	47,3(±5,5)	47,4±(3,5)	47,9±(4,8)	45,4±(3,1)	44,8±(3,3)	42,4±(1,7)*

DISCUSSION

Evidence of muscle damage was demonstrated by the increased CK level and muscle soreness, and loss of maximal voluntary torque 24h after exercise. Deficit in isometric torque was only greater when it was compared with eccentric torque measured at the first peak of SSC. As stretching energy increased magnitude of loss in MSC2 linearly increased, showing that EIMD has more negative effect if greater load is applied in the test exercise. Surprisingly, manipulation of stretching energy had no effect on the pre-to-post change of MSC1. At the beginning of a sudden stretch torque is exerted mostly by the passive connective tissue (short range stiffness), and it was possibly less influenced by EIMD. MSC2 was however more affected by EIMD probably because more contractile elements were expected to be recruited to produce torque, but these fibers were damaged. This may also explain the interesting finding that mechanical efficiency did not change in the 120 and 150J conditions, whilst it decreased in the 180J condition. In SSC tests lower stretching energy may result in smaller angular displacement, and stiffness may facilitate mechanical efficiency rather than gets lost, as it may have happened in the 180J condition. Lack of deficit in mechanical efficiency during SSC exercise can also be explained with the compensating mechanism of the increased angular displacement in knee joint after EIMD.

CONCLUSION

If individuals are trained consecutively and EIMD is present, type of the exercise contraction must be considered when magnitude of strength loss is a question. Loss of muscle function in SSC exercises may be more severe if higher load is applied. In SSC exercises where angular displacement is small due to small load, mechanical efficiency may not be influenced by EIMD.

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ACUTE RESPONCES IN MUSCLE HYPERTROPHY SIGNALLING TO A MORNING VS. AFTERNOON RESISTANCE EXERCISE PROTOCOL

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INTRODUCTION

Time of day has been shown to affect various indices related to neuromuscular performance in both acute responses and long-term adaptations to resistance training. Voluntary maximum muscle strength is typically significantly lower in the morning compared to the afternoon [1]. Lower morning performance can be improved to the afternoon levels by regularly training in the morning hours over period of several weeks [2]. Much less is known with regards to hypertrophic adaptations to resistance training. To date, the only study performed on humans found a tendency to slightly smaller gains in muscle size when repeatedly training in the morning compared to the late afternoon [3]. One of the possible mechanisms contributing to above-mentioned time-of-day depended training adaptations are signalling pathways involved in the control of protein synthesis. Phosphorylation of specific proteins in Akt/mTOR/p70S6k and also in mitogen-activated protein kinases signalling pathways have been shown to positively regulate muscle growth [4,5]. The main purpose of this study was to examine effects of the time of day on phosphorylation levels of selected proteins and maximum voluntary muscle strength when resistance exercise is performed either in the morning or afternoon hours.

METHODS

Twenty-two healthy, previously untrained men (mean ± SD, age 24 ± 3 yrs, body mass 77.4 ± 5.82kg, height 181 ± 8.35cm) were pre-tested for isometric maximum voluntary bilateral leg extension at the knee angle 107º (MVC) between 11:00h and 14:00h. Thereafter, participants were pair-matched based on MVC and body mass index and randomly divided into two time-specific resistance loading groups: Morning (M, n=11) and Afternoon (A, n=11). Five to seven days after the pre-test the M and A groups were tested between 07:30-08:30h and 16:00-17:00 h, respectively. The test included 3 trials of MVC (Pre MVC), followed by 5 sets of 10 repetitions of maximum isokinetic bilateral leg extensions. Two minutes after the acute resistance exercise protocol 3 trials of MVC were carried out again (Post MVC). All MVC tests and the exercise protocol were performed on a computer controlled linear motor-powered leg press dynamometer. A trial with the highest peak force was taken for further analyses. Thirty minutes before and sixty minutes after the acute resistance loadings, muscle biopsies were taken from the right and left vastus lateralis, respectively. Muscle biopsy specimens were frozen immediately in liquid nitrogen (-180°C) and stored at -80°C. Specimens were later homogenized and analysed for phosphorylation of Akt (Ser473), p70S6 (both Thr389 and Thr421/Ser424), rpS6 (Ser240/244), p38MAPK (Thr180/Tyr182), Erk1/2 (Thr202/Tyr204), and eEF2 (Thr56) by Western blot technique. Proteins were visualised and quantified by enhanced chemiluminescence method.

RESULTS

Resting muscle force was similar in both groups (3372 ± 983 N and 3447 ± 1202 N in the M and A group, respectively) and it declined significantly after acute resistance loading with no statistical difference between morning and afternoon (2062 ± 372 N and 2147 ± 693 N in the M and A group, respectively). Levels of phosphorylated p70S6^{Thr389}, p70S6$^{Thr421/Ser424}$, rpS6$^{Ser240/244}$, p38MAPK$^{Thr180/Tyr182}$ isoforms alpha/beta and gamma were significantly higher after acute resistance loadings ($P<0.01$ in all, GLM acute loading-main effect). When examined separately group by group, the A group had significantly greater phosphorylation of p38MAPK alpha/beta isoform ($p<0.001$, paired samples t-test) compared to the M group. The A group had down-regulated phosphorylation of eEF2 ($p<0.05$, paired samples t-test) that did not changed in the M group (Fig. 1). Phosphorylated Akt and Erk1/2 did not statistically change due to exercise or the time of day.

DISCUSSION

The main finding of the present study was that the time of day seemed to affect post-exercise levels of phosphorylated eEF2 and p38MAPK. Phospho-eEF2 decreased after exercise in line with previous findings [6] but significantly only in the afternoon, indicating increased activity of eEF2 and thus protein synthesis translation elongation capacity [7]. Both isoforms of phospho-p38MAPK are important for muscle metabolic adaptations and showed elevation due to exercise but only p38 alpha/beta showed statistically significant differences between morning and afternoon hours, This was apparently caused by a larger inter-individual variation in the A group, which may be actually an effect of the time of a day per se. Phosphoproteins within the Akt/mTOR/p70S6k pathway (p70S6 ^{Thr389}, p70S6 $^{Thr421/Ser424}$, and rpS6 $^{Ser240/244}$) were significantly elevated after exercise but with no evidence of a time-of-day effect. Somewhat larger levels of post-exercise phosphorylated p70S6 $^{Thr421/Ser424}$ compared to p70S6 ^{Thr389} could be due to nutritional status (low intake of branched-chain amino acids in the morning) and exercise selection with prominent eccentric loading [8,9]. Also a two-fold higher mean increase of phospho-Akt in the afternoon compared to the morning, although statistically non-significant, was most likely related to differences in the nutrition status. It can be speculated that the present findings on eEF2, p38MAPK, and Akt may, in part, explain larger hypertrophy adaptation observed earlier [3]. Contrary to the previous findings, the time of day had no effect on voluntary muscle strength production or fatigability.

CONCLUSION

Phosphorylated levels of p38MAPK and eEF2 seemed to be differentially responsive to a bout of resistance exercise performed in the morning compared to the afternoon. On the contrary, signaling through the Akt/mTOR/p70S6k pathway may be independent of the time of day of loading.

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Supported by a grant from Iceland, Liechtenstein and Norway through the EEA Financial Mechanism and the Norwegian Financial Mechanism. This project was also co-financed from the state budget of the Slovak Republic.

NEUROMUSCULAR AND HYPERTROPHIC ADAPTATIONS FOLLOWING CONSTANT AND VARIABLE RESISTANCE TRAINING IN YOUNG AND OLD MEN

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INTRODUCTION

Variable resistance has been shown to produce greater muscle activation compared to constant resistance [2, 5], as the resistance at certain parts of the range of motion is higher. This has also led to greater acute neuromuscular fatigue [3, 5] and larger hormonal responses during loadings [5]. These findings suggest that long term training with variable resistance devices may give an advantage over traditional, constant resistance training. However, previous studies have produced equivalent results in young men [4]. The aim of this study was to determine whether differences could be observed in strength, total work, muscle activation, and hypertrophic adaptations between constant and variable resistance methods over a 20 week training intervention in young and old men.

METHODS

Thirty five young men and thirty eight old men were randomly assigned to either constant or variable resistance training (Young constant; Ycon N = 12, ~27yrs, Young variable; Yvar N = 13, ~29yrs, Old constant; Ocon N = 13, ~65yrs, Old variable; Ovar N = 14, ~65yrs) or a non-training control group (Young control; YC N = 10, ~30yrs, Old control; OC N = 11, ~65yrs). The subjects were recreationally active but did not participate in regular resistance training. The training groups completed two repeated periods of 10 weeks (20 training weeks in total), which consisted of whole body hypertrophic training of progressively increased intensity, while maintaining overall volume (repetitions per set reduced from 12-14 during the first four weeks to 8-10 repetitions during the last three weeks). Lower limb exercises were the leg press, knee extension, and knee flexion. Measurements consisted of maximal bilateral isometric leg extension, maximal unilateral knee extension and flexion, and bilateral leg press 1RM and repetitions to failure using the current 75%1RM. Muscle activation was determined for the vastus lateralis (VL) and vastus medialis (VM) muscles during the aforementioned tests. Body composition and muscle mass (lean leg mass) were determined by DEXA scans. All tests were carried out pre-, mid-, and post-training, except for the control groups who were tested at pre-, and post-training.

RESULTS

Maximum isometric bilateral leg extension force increased pre- to mid-training in the Yvar (Δ ~16%), Ovar (Δ ~17%), and Ocon (Δ ~15%) groups ($p < 0.01$) with Ovar and Ocon maintaining these improvements post-training. Maximum 1RM improved in all training groups without group differences. The repetitions to failure test showed that total work (calculated by volume load) increased in Yvar from pre- to mid- training (Δ ~32%, $p < 0.05$) and pre- to post-training (Δ ~50%, $p < 0.01$). Trends ($p = 0.053$) were observed for Ovar improvements mid- to post-training, and in relative changes, pre- to post-training, of the pooled variable group (young and old) versus control ($p = 0.051$). Although the mean results of both constant groups increased, they did not reach statistical significance. There was no change in the control groups for these variables.

Averaged vastii ((VL+VM)/2) muscle activation during maximal isometric leg extension increased in Ocon only, although the pooled old men data (Ovar and Ocon) also showed increased activation ($p < 0.01$). The pre- to post-training relative changes in averaged vastii muscle activation was greater in both Ovar and Ocon compared to OC ($p < 0.01$). Similarly, during isometric knee extension, both Ovar and Ocon increased averaged vastii muscle activation pre- to post-training.

Significant relationships were observed between relative changes in maximum isometric leg extension force and muscle activation in the old ($r = 0.452$, $p < 0.05$, $n = 24$) and lean leg mass in the young ($r = 0.559$, $p < 0.05$, $n = 20$).

DEXA data revealed significant lean leg mass increases in Yvar (~3.3%) and Ycon (~3.7%) at mid- and post-training ($p < 0.05$). Additionally, the increases in both young training groups were significantly greater than YC ($p < 0.01$). Whole body fat percentage decreased in all training groups at mid-training, with no further changes mid- to post-training.

DISCUSSION

Maximum isometric force increases were observed in Yvar, Ovar, and Ocon with a similar magnitude to previous studies [1]. Maximum strength improvements, which plateaued after 10 weeks in the current study, may not best reflect training induced changes between constant and variable resistance during medium intensity, high volume training [4]. However, through a training specific test (reps to failure using 75%1RM, more representative of hypertrophic training) it appears that variable resistance training is more advantageous in both young and old subjects. In contrast to maximum strength, total work continued to improve throughout training. The results suggest that fatigue resistance of the neuromuscular system has improved to a greater extent due to variable resistance training. This may be particularly relevant to various athletic groups where repetitive high force levels are needed, and also functional and manual work capacity in the general population of different ages, than pure maximum strength or endurance.

Interestingly, changes in force were more closely related to neural adaptations in the old men, while in the young, changes in force were related to muscle hypertrophy changes. Therefore, neural adaptations in the early phase of strength training may occur more in OM compared to YM, even during hypertrophic training.

CONCLUSION

This is the first study to indicate that variable resistance training may be more beneficial than constant resistance training, even in untrained subjects, where it is difficult to detect differences between two training regimens. It is, therefore, important to use a training specific test to determine group differences. Total work results also suggest that improved fatigue resistance of the neuromuscular system during variable resistance training was not related to muscular hypertrophy per se.

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BIOMECHANICAL AND MORPHOLOGICAL EFFECTS AFTER TEN WEEKS OF SUBTALAR JOINT SPECIFIC PRONATOR AND SUPINATOR STRENGTH TRAINING IN REARFOOT RUNNERS

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INTRODUCTION

Several overuse running injuries have been linked to excessive rearfoot motion [3]. Although bio-positive effects after strength training interventions have been observed [1,2], the role of shank muscle strength is not well understood. Purpose of this study was to identify the morphological and biomechanical effects of functional pronator and supinator strength training. For an efficient strengthening of the pronators and supinators a new training machine was developed with its rotational axis aligned to the subtalar joint axis as identified by Inman [4]. It was hypothesized that the specific training of the deep plantarflexors (TP=m. tibialis posterior; FHL=m. flexor hallucis longus; FDL=m. flexor digitorum longus) and the peroneal muscles will stiffen the ankle joint complex and reduce the subtalar range of motion during ground contact in running.

METHODS

Study Design

The Study was conducted as an intervention study. At the beginning of the test period every subject had to undergo a pre-test (PRE) with muscle strength and biomechanical testing as well as muscle volume measurements. The pre-test was followed by the group specific intervention. After the ten-week training the same measurements were performed in the post-test (POS).

Functional Pronator/Supinator Strength Training Machine (FPSM)

The FPSM consisted of a foot apparatus which was adjustable in all three dimensions. The movement axis was orientated in parallel to the subtalar joint axis which deviated about 23° to medial and about 42° to dorsal from the longitudinal foot axis [4]. The foot apparatus was connected via a driven cardan shaft and a pull rope to the weight block. A sport shoe (size US 10) was mounted onto the foot plate and the forefoot additionally fixed with a belt. So it was possible to train in a seated position the pronators and supinators of the foot within their functional anatomic movement plane.

Intervention

30 healthy male rearfoot runners (age: 26.4 years; height 1.81 m; mass: 78.5 kg) went for a 10 week strength training (3 sessions per week) performing a single-set high resistance strength training of the shank muscles with single leg exercises. The participants were randomly assigned into a control group (n=8) and an experimental group (n=22). The control group (n=8) performed a plantarflexor and dorsiflexor training at traditional training machines. The experimental group performed a supinator and pronator strength training of the right leg by using the FPSM. The left leg served as an intraindividual control condition and was also trained by plantar-/dorsiflexions.

Biomechanical Testing

To compare the training effects of traditional plantar/dorsiflexor training with functional pronator/supinator strength training maximum isometric pronation and supination torque was measured by using two force transducers (Kistler 9321A) placed between the driven shaft and the machine frame of FPSM. During shod running across a Kistler force plate in 3.3 m/s rearfoot motion (electrogoniometer) were measured. The subjects ran in two test conditions: A=regular running shoe; B=same shoe with inserted valgus wedges (height difference: 6mm).

Additionally, the volume of the muscles from both lower legs was quantified by magnetic resonance images (3 Tesla, Philips Intera Archievera) of 9 randomly chosen test persons of the experimental group. The results were analyzed with a two-way repeated measures ANOVA.

RESULTS

The intraindividual comparison of the right and left experimental leg (functional pronator/supinator training (FPST) vs. plantar/dorsiflexortraining (PD)) revealed specific training effects. Compared to PD, FPST resulted in significantly higher pronator (14% vs. 8%, $p<0.01$) and supinator MVC (25% vs. 12%, $p<0.01$). Both, FPST and PD increased the supination angle at touchdown in running for both shoes A, B ($p<0.01$). In shoe B pronation velocity was reduced about 16% in FPST (FPST vs. PD: $p<0.01$) and delayed (FPST: +23%; PD: +3%; $p<0.05$). The median power frequency of the vertical ground reaction force signal increased in A ($p<0.05$) and B ($p=0.05$). MRI recordings showed training specific increase in muscle volume of TP (+10%; FPST vs. TT: $p=0.2$), and FHL (+6%; FPST vs. PD: $p=0.09$) after FPST. No leg dominant effects in any outcome measures were observed in the control group.

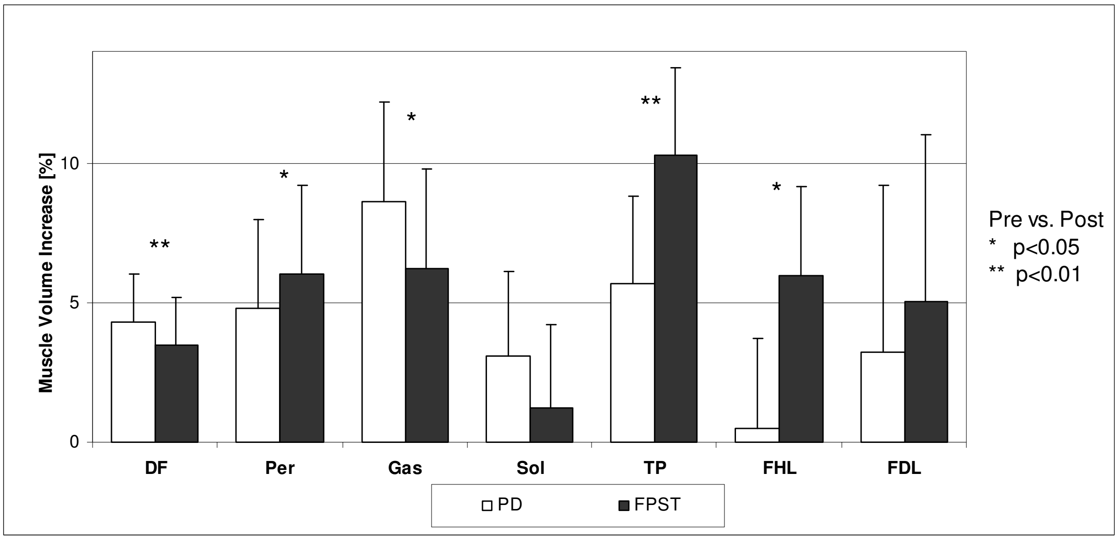

Figure 1. Training specific muscle volume increase in shank muscles (mean values, standard errors). Dorsiflexors (DF), peroneal muscles (Per), m. gastrocnemius (GAS), m. soleus (SOL), m. tibialis posterior (TP), m. flexor hallucis longus (FHL), m. flexor digitorum longus (FDL).

DISCUSSION

Both, FPST and PD induced strength gains that stiffened the ankle joint complex and increased supination angle at touchdown in running. Compared to PD, the muscular control of rearfoot motion is enhanced after FPST. After FPST the runner seems to benefit from the higher muscular tension before ground contact and the higher resulting braking distance while maximum pronation is not changed. It can be concluded that the specific strength increase of the deep plantarflexors FHL and TP leads to a smoother pronation behavior with reduced and delayed pronation velocity, especially, when a higher amount of pronation is induced (shoe B).

CONCLUSION

Our findings reveal that functional subtalar joint strength training is an effective protective mechanism against excessive rearfoot motion in running. A combination of lower leg strength training and appropriate footwear might be a new approach for the prevention and treatment of overuse injuries in running. Future clinical studies might show the preventive potential of subtalar joint specific strength training in participants with overuse running injuries.

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STRENGTH AND POWER IN WHEELCHAIR ATHLETES

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INTRODUCTION

Studies dealing with spinal cord injury (SCI) patients and athletes have focused on analyzing endurance training, metabolic and cardiorespiratory fitness. Several studies found impaired performance in these subjects due to "unique changes in metabolic, cardiorespiratory, neuromuscular and thermoregulatory systems, which reduce their overall physiological capacity" [1, p. 26]. In contrast, little is known about strength and power in SCI subjects, especially in athletes performing competitive wheelchair sports.

Although some wheelchair sports are of growing popularity as recreational and competitive sports there is also a lack of knowledge regarding guidelines for specific training designs, especially in strength training. Most wheelchair sports depend on strength and power of upper extremities and these abilities should be developed explicitly by heavy resistance training. It is questioned if training regimes of high performance athletes could be transferred to training in wheelchair sports. In this context we performed two studies. In the first study (I) we evaluated strength and power properties in upper extremities in wheelchair athletes comprehensively. In the second study (II), we investigated effects of an eight-week program consisting of heavy-resistance exercises.

METHODS

(**I**) Twenty-five male subjects participated in the first study - thirteen with SCI and twelve healthy physical education students conversant with strength training. First, established measurements were modified for analyses with SCI-subjects. Second, several power and strength parameters were evaluated in upper extremities in all subjects in standardized positions and conditions. Subjects' performances were tested in isometric as well as in dynamic actions: Movement speed was analyzed in a Smith machine by measuring maximal velocity and maximal acceleration of the barbell. Maximal strength and maximal rate of force development (MRFD) were evaluated by measuring force-time curves in isometric condition. Moreover, we evaluated one repetition maximum (1RM) and strength endurance (repetitions with a weight representing 60% of the individual 1RM). Moreover, we recorded EMG-activity of upper extremities muscles (Triceps brachii, Biceps brachii, and Pectoralis major).

(**II**) Sixteen male subjects participated in the second study - eight with SCI and eight healthy physical education students. The subjects participated in an eight-week program consisting of heavy-resistance exercise performed twice per week. Each training session consisted of 10 to 12 repetitions in 5 sets. Training exercise was bench press. All exercise sessions were individually surveyed and supervised as SCI subjects have often difficulties during exercises in stabilizing their upper part of the body because of lack of muscle strength and coordination deficits. Subjects' performances were tested three times: before starting the eight-week program, after finishing the training program and one week afterwards. We measured the same parameters in isometric and in dynamic actions as in the first study. Additionally, we tested 10m-sprinting performance in wheelchair athletes.

In both studies athletes with SCI were wheelchair basketball or wheelchair rugby players in the first national leagues or in the national team.

RESULTS

(I) Overall, analyses of group differences showed no significant differences between wheelchair athletes and physical education students, both for strength and power properties in the isometric condition (p-values between 0.483 and 0.914) as well as in the dynamic condition (p-values between 0.156 and 0.421). But in static condition wheelchair athletes showed a tendency to advantage in maximal strength and in rate of force development. And physical education students show a tendency to advantage in maximal movement velocity in dynamic condition.
(II) Overall, both groups showed again similar results: In all parameters we measured an improved performance in post-testing – in wheelchair athletes as well as in physical education students. Increases ranged between 4.2% and 31.6%. But the level of significance ($p \leq 0.05$) was not reached in pre-post comparisons. In most strength and power parameters wheelchair athletes showed a tendency to a higher profit from the strength training used in this study. But using analyses of group differences only the comparison of effects on MRFD showed a significant advantage for wheelchair athletes ($p=0.01$). In 10 m-sprinting performances we found no improvement due to strength training.

DISCUSSION

Data from our first study demonstrate that there is overall no group difference of strength and power properties between wheelchair athletes and physical education students conversant with strength training. But in interindividual analyses SCI-subjects showed a much stronger variation of results. Furthermore, in interindividual comparisons of EMG data we found different coordination patterns depending on the classification of motor ability. A reason for this lies in the fact that wheelchair athletes have a spectrum of functional abilities depending on the level of spinal cord injury. Most wheelchair basketball players have the lesion at the level of the lumbal vertebrae (called Paraplegia) leading to no impairment of upper extremities. Wheelchair rugby players, on the other hand, are tetraplegic with a spinal cord injury at the level of the cervical vertebrae leading to impairment affecting functional abilities of upper extremities as well.
Our data from the second study indicate that wheelchair athletes and physical education students show similar effects of heavy resistance-training on strength and power properties in upper extremities. In contrast to hitherto assumptions about minor adaptation capacities to training exercises in SCI-patients, our study showed clear effects of strength training. Some wheelchair athletes participating in this study were tetraplegic. Nevertheless, they showed strong improvements in nearly all strength and power parameters due to heavy resistance-training lasting eight weeks. In MRFD we demonstrated a prominent and significant difference between wheelchair athletes and control subjects. Besides real effects of strength training and despite of habituation sessions before pre-tests, we speculate about stronger learning and habituation influences on testing situation in these subjects. It is difficult to compare these results with data from the literature as we are unaware of any reports showing effects of comparable training regimes on power and strength parameters in wheelchair athletes [2]. Most studies cope with strain of daily activities and rehabilitation of patients to maintain a certain level of physical activity and promoting functional independence. Accordingly, they used merely moderate intensities in exercises like wheelchair ergometer, kayak ergometer, hand cycling, arm cranking, and circuit training but not heavy resistance training.

CONCLUSION

In conclusion, the present studies proved that strength training with heavy resistance may provide functional value to optimize performance in competition in individual sports such as wheelchair athletics (e. g. sprinting and throwing) and in team sports such as wheelchair basketball.

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Thursday 16:30-18:15

Defended Poster Session I

STRENGTH TRAINING ASSOCIATED TO SPECIFIC PLYOMETRICS: THE DEVELOPMENT OF VERTICAL IMPULSE STRENGTH IN FEMALE VOLLEYBALL PLAYERS

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INTRODUCTION

Most sports abilities, as in most human activities, require reactive movement which is the combination of eccentric and concentric muscular contractions. And this natural form of muscular function is known as a Stretch-Shortening Cycle (SSC). Plyometric training has been one of the most popular methodologies for developing explosive strength along with rapid force in SSCs. This induces a rapid transition from eccentric to concentric muscle work. By using SSCs, the muscle structure will be able to produce an increased amount of positive work (greater impulse) than in merely concentric actions.

When planning a plyometric training programme, one should respect the specificity training principle. Therefore, when selecting plyometric exercises, for example with volleyball players, these should be in accordance with the dynamic body structure and technical abilities of vertical jumps. To achieve this, one must analyse the angular motion from the main articulations involved in the action, the motion speed of each body segment as well as ground contact times. This methodology must emphasise the importance of concentric action, which is without a doubt, the most important contraction phase for attaining maximum performance from each blocking and/or spiking action. Whenever assigning plyometric exercises, a technical specificity is present in our specific plyometrics programme. Besides, vertical impulse actions are dominantly SSC_{long} (a duration of 200ms and accentuated joint angle) and have an emphasis on contractile muscular actions of high tension at the beginning of the concentric phase.

The purpose of the present study was to analyse the effect of a general strength training programme combined with a specific plyometrics programme upon the vertical jump height and the strength development of the lower limbs in high performance female volleyball players.

METHODS

Our sample was composed of 11 female volleyball players (aged 21,8 ± 2,4), who participated in the Major League of the National Volleyball Championship Playoffs at the time. Evaluation took place before and after the strength training programme and involved the following strength tests for vertical jumps: Squat Jump (SJ), Counter Movement Jump (CMJ), Drop Jump 40 cm (DJ 40), Block Jump and Spike Jump.

As stated, the strength development programme was carried out throughout twelve weeks. The training programme was divided into two phases: hypertrophy and neural adaptation training. The strength exercises were the following: leg press; leg extension; leg flexion; calf muscles; triceps; lat pull; butterfly and bench press.

Our specific plyometric programme was essentially based on the use of SSC_{long} exercises. The aim was to increase the speed of the exercise so as to attain an increase of SSC force development during the shortest time period. The combination of concentric and eccentric actions was similar to the speed and strength of the muscular contraction used in technical abilities to be performed in competition. Arm, trunk and head movements contributed to increase performance in jumping. Therefore we believe, greater concentric action (positive jump phase) is the most important phase for high jumping performance in volleyball, particularly when blocking or spiking.

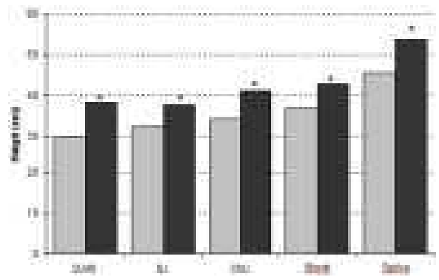
RESULTS AND DISCUSSION

As shown in table/figure 1, our results demonstrate that the training group had statistically significant increases in all vertical jump tests performed between the two evaluation moments.

After analysing all the data one verified that absolute and relative increases were as follows: 8.6cm (22,6%) for DJ, 5cm (14,2%) for SJ, 7cm (16,4%) for CMJ, 6cm (13,8%) in blocking and 8,2cm (15,4%) in spiking.

Table and figure 1. Mean values of explosive and reactive strength tests between two evaluation moments.

	Before		After		Increases			
	Mean	± SD	Mean	± SD	Abs.	%	t	P
SJ (cm)	32,4	9,3	37,5	8,2	5,1	14,2	-2,87	0,000*
CMJ (cm)	34,1	8,1	41	7,8	6,9	16,4	-3,43	0,006*
DJ40 (cm)	29,6	5,9	38,2	5,6	8,6	22,6	-8,13	0,000*
CMJbl (cm)	36,8	7,6	42,7	7,9	6,9	13,8	-7,42	0,000*
CMJsp (cm)	45,7	8,1	53,8	7,7	8,2	15,4	-10,1	0,000*



* Statistically significant differences ($p \leq 0.05$)

From the mean value analysis, we must emphasise that the greatest jumping height increase was in the spiking test, immediately followed by blocking. This is not surprising because both tests were much similar to specific volleyball technical abilities, as stated previously. The main goal of our specific plyometric training programme was to amplify exercise specificity in order for it to be as similar as possible to the main jumping abilities in volleyball.

CONCLUSION

Our main results were the following: a combined lower limb general strength training and specific plyometric programme of concentric action emphasis and exercise specificity (as close as possible to the real competitive technical jumping ability) induced considerable gains in strength output, more precisely in the explosive and reactive strength (evident in SJ, DJ_{40}, CMJ, Block Jump and Spike Jump test results).

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EFFECTS OF ESTROGEN ON MUSCLE DAMAGE IN RESPONSE TO AN ACUTE RESISTANCE EXERCISE PROTOCOL

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INTRODUCTION

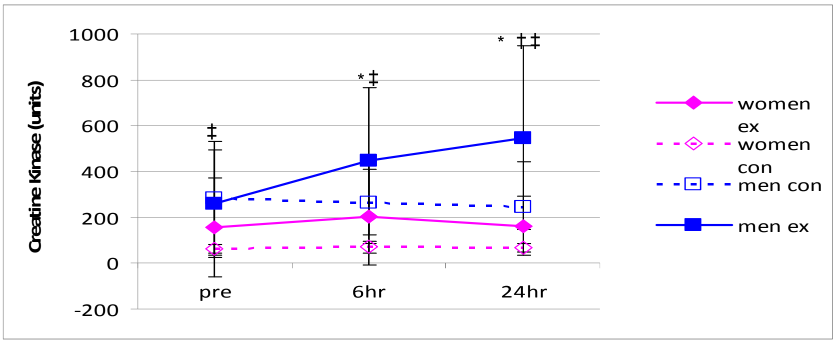
Eccentric exercise poses a structural strain on skeletal muscle, disrupting the sarcolemma, sarcoplasmic reticulum, and Z-lines[1,2]. This disruption can cause muscle proteins and enzymes such as creatine kinase (CK) to leak into the interstitial fluid. Creatine kinase concentrations are influenced by several factors including training status and gender[1,3]. Trained individuals present a higher concentration of CK activity compared to untrained individuals[2,3]. Men have higher basal concentrations of CK compared to women. Furthermore, several reports have shown that women have lower CK activity following exercise[1,5,6,7]. Moreover, women have been found to be more prone to initial functional losses but have faster recovery rates than men who lost similar initial strength after exercise [2]. Estrogen has been hypothesized to mediate this gender discrepancy. Thus, the purpose of this study was to characterize gender differences in creatine kinase as a marker of muscle damage in response to an acute heavy resistance exercise protocol. Furthermore, we wished to determine if circulating estrogen concentrations were related creatine kinase changes.

METHODS

Seven healthy, resistance-trained, eumenorrheic women (23±3 y, 169±9.1 cm, 66.4±10.5 kg) and 8 healthy, resistance-trained men (25±5 y, 178±6.7 cm, 82.3±9.33 kg) volunteered to participate in the study. Subjects performed an Acute Resistance Exercise Test (ARET) consisting of 6 sets of 5 repetitions Smith machine squats at 90% of their previously determined 1-RM. The control condition required the subjects to sit for 2 hours under similar conditions and at the same time of day as the exercise, with blood draws and scale sets provided at the same time points. Blood samples were taken pre-, mid-, post-, 1 hour post-, 6 hours post-, and 24 hours post-exercise. Samples were stored at -80ºC until analyzed. Serum creatine kinase was measured using an assay kit from Genzyme (Framingham, MA). Serum estradiol was measured by an ELISA from GenWay (San Diego, CA). Estradiol β-receptor presence on granulocytes was measured via flow cytometry using primary antibodies from Abcam (Cambridge, MA) and PeCy7 antibodies (secondary) from Santa Cruz (Santa Cruz, CA). Subjects also completed general soreness scale from one to five at pre-, post-, +6HR, and +24HR time points. Data are presented as mean ± SD. Data were analyzed using a gender x condition x time repeated measures ANOVA. Fisher's least significant difference post hoc test was used to determine pairwise differences when an *F* score was significant. Mauchly's Test of Sphericity was used to assess homogeneity of variance in the repeated measures design. A Greenhouse-Geisser correct was used if Mauchly's Test was significant. One-way ANOVA was used to analyze significant between men and women in physical characteristics and the baseline characteristics in exercise and control conditions. $P \leq 0.05$ was considered significant.

RESULTS

No significant correlations between estrogen and CK response were found after an acute resistant exercise protocol. Moreover, no significant changes in estradiol receptors were expressed on granulocytes after exercise. Creatine kinase response, however, differed significantly between genders. Men had higher resting CK concentrations throughout all time points. Creatine kinase response increased significantly after exercise in both men and women ($p=0.008$, $F=9.798$). Men had a significantly higher CK response at 24 hours post exercise than women. A significant condition/sex/time interaction was exhibited in CK response (p=0.02, F=4.547). Perceived general soreness presented a significant condition, sex interaction (p=0.01, F=9.532).



*P ≤ 0.05 between conditions for both men and women
† P ≤ 0.05 between genders after exercise
‡ P ≤ 0.05 between genders at control

Figure 1. Creatine Kinase response showed a significant condition x time x sex interaction (p=0.02, F=4.547). Men had significantly higher resting CK levels. Values are means ± SD, CK significantly increased in the exercise condition compared to control in both men and women (p=0.008, F=9.798). Men furthermore had a significantly higher CK response than women at +24HR.

DISCUSSION

Although no estradiol and CK response correlations were found in response to exercise, a significant difference in creatine kinase activity was present between men and women. This discrepancy of our results and findings in the literature may be due to the high variability between subjects in creatine kinase activity as well as estrogen concentrations. The lack of significance in change of estradiol receptor expression on granulocytes in response to exercise may be due to intracellular estradiol receptor staining and non-specific gating for granulocytes rather than additional staining for neutrophil markers. Because neutrophils are the initial cells present in the inflammatory response after strenuous exercise, staining for estrogen receptors on this cell type may allow for a better understanding of the effect of estrogen and its hypothesized protective effect against muscle damage. Furthermore, the mechanism of action may include estradiol receptor expression on the muscle fiber itself may play a role in the protective effects of estradiol rather than or in addition to expression on neutrophils. We have shown here that gender differences occur in CK activity as a marker of muscle damage in response to strenuous eccentric exercise, but may not be the result of estradiol concentration or estradiol receptor expression on granulocytes.

CONCLUSION

Other variables should be examined in order to determine the mechanism involved in the difference in creatine kinase as a marker of muscle damage between men and women after heavy resistance exercise.

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TRUNK MUSCLE STRENGTH THREE MONTHS AFTER LUMBAR SPINE FUSION

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INTRODUCTION

The chronic low back pain and spine surgery may lead to structural and functional changes of the trunk muscles and those changes can increase disability of patients. There is only limited amount of data about effects of lumbar spinal fusion on the physical function after operation [3]. The aim of this study was to evaluate the early effect of lumbar spinal fusion on trunk muscle strength and its relation to pain and disability measured before and 3 months after surgery.

METHODS

Altogether 114 patients (36% males, age 57 ±13 and 64% females age 61±11) who had undergone lumbar spine fusion volunteered to the study as part of a larger spine register study in Tampere University Hospital and Jyväskylä Central Hospital. Isometric trunk muscle extension and flexion strength was measured by a strain-gauge dynamometer [6]. Measurements were performed in a standing position. During measurement the hips were fixed at the level of anterior superior iliac spine and another support was under the knees. A harness was fastened around the shoulders and chest just below armpit and this was horizontally attached to a strain-gauge dynamometer with a metal lock. Two maximal efforts were performed. If the measured strength level increased more than 10% from the first effort, one additional effort was performed. The best result was used in the analysis. Oswestry Disability Index (ODI, 0-100 scale) was used to evaluate disability. Scores are defined by a scale: 0-20 minimal, 20-40 moderate and 40-60 severe disability. A score 60-80 indicates a crippled patient and 80-100 indicates that patient is either bed-bound or exaggerating their symptoms [5]. Visual analogue scale (VAS, 0-100 scale) was used to evaluate pain during the strain [1]. Patients were advised to walk and perform light home exercises during first three months after surgery.

RESULTS

Pre-operatively the trunk extension and flexion strength levels were in males 319 N and 436N, and in females 160N and 214N, respectively. The increases of 39 N (95% CI (18 to 59) in trunk flexion and 38N (95% CI (18 to 59) in extension strength were statistically significant in females in the 3 months follow-up measurement ($p<0.001$) while in males strength levels remained unchanged. Post-operatively the strength of trunk extensors and flexors were in males 36% and 55%, and in females 29% and 36% of body weight, respectively. Preoperatively extension/flexion strength ratios were 0.76 for males and 0.79 for females. Three months postoperatively strength ratio was decreased to 0.66 for males ($p<0.05$). There was significant association between pain and extension [r= -0.38 (95%CI: - 0.55 to -0.18)] and flexion [r= -0.25 (95%CI: - 0.45 to -0.03)] strength measurements in females. The ODI decreased from 39 to 23 in males ($p<0.001$) and from 45 to 23 in females ($p<0.001$) during follow up. The changes in the ODI associated moderately with changes of trunk extension [r= -0.38 (95%CI: -0.50 to -0.23)] and flexion [r= -0.43 (95%CI: - 0.58 to -0.27)] strength. (Fig 1)

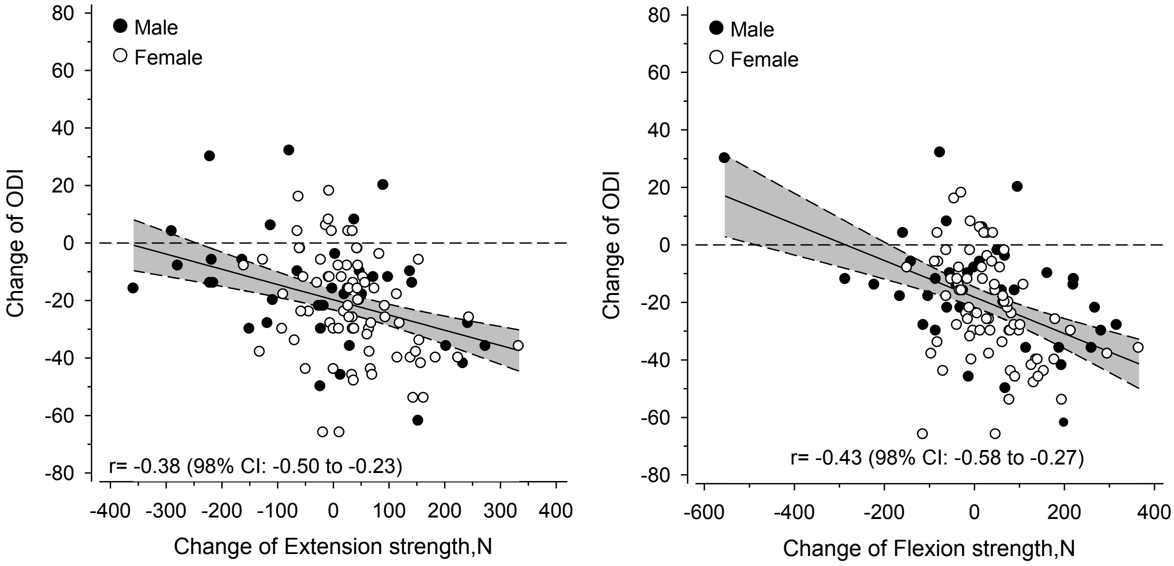

Fig. 1 The association between change of trunk (a) extension strength and (b) flexion strength and change of ODI

DISCUSSION

Although the muscle strength increased statistically significantly in females the patients still had low trunk extension and flexion strength level 3 months postoperatively. The function of trunk extensors and flexors was in imbalance because extension/flexion strength ratio that normally is over 1.0 was less than 0.8 in both genders [4]. Similar changes of the trunk muscle strength have been noticed also after lumbar disc surgery [2]. Measurement pain only weakly associated with strength values in females thus the reasons to low strength values are more probably other than just pain inhibition related. All patients had long back pain history that may lead to disuse of trunk muscles and cause biomechanical e.g. muscle atrophy and decreased muscle activation or psychological changes e.g. fear of pain and fear of movement. The correlation between muscle strength and ODI indicate that increase of muscle strength may decrease disability of these patients.

CONCLUSION

Light home exercises done during the early recovery were not enough to normalize back function, thus intensive rehabilitation will be needed to normalize trunk muscle strength and to decrease disability after lumbar fusion operation. The trunk muscle strength measurements can be used in the follow-up and motivating of patients.

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KNEE LIGAMENT LOADING DURING VERTICAL JUMPING AND PUSH JERKING

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INTRODUCTION
Injuries to the ligaments of the knee are common occurrences in sport [6]. Despite this, little is known about the forces experienced by the knee during athletic activities. The purpose of this study was therefore to quantify the knee ligament and joint contact forces during vertical jumping and push jerking.

METHODS
In this study a previously described [2,3] musculoskeletal model of the lower limb was used to calculate the knee ligament loading during vertical jumping and push jerking (40 kg). Motion capture (Vicon MX System, Vicon Motion Systems Ltd, Oxford, UK) and force plate (Kistler Type 9286AA, Kistler Instrumente AG, Winterthur, Switzerland) data was recorded from 12 athletic male subjects (age 27.1 y ± 4.3; mass 83.7 kg ± 9.9; height 1.786 m ± 0.074; maximum vertical jump 0.38 m ± 0.05). The musculoskeletal model consisted of four linked rigid body segments that represent the right lower limb. The musculoskeletal geometry of the model was taken from the work of Horsman and colleagues [5]. Optimization techniques (in Matlab) were used to solve the three dimensional equations of motion of the model [2,4] where the outputs of this process were individual muscle forces for 163 distinct muscle elements and the forces in the collateral ligaments. These forces were then in turn employed to calculate cruciate ligament loading and joint contact forces (tibiofemoral (TFJ) and patellofemoral (PFJ) joint contact forces).

RESULTS
The magnitude of the mean peak knee ligament loading varied from 0.1-2.4 × BW. Generally, the PCL experienced the highest loading, followed by the ACL (Table 1). The magnitude of the mean peak TFJ and PFJ loading ranged from 7.9-10.6 × BW and 2.4-5.1 × BW, respectively. During jump takeoff, the PCL was loaded for the bulk of the movement, with a brief period of ACL loading immediately before takeoff (Figure 1). During landing the loading of the cruciate ligaments varied rapidly between ACL and PCL loading, with a sustained PCL loading later in the landing phase. The collateral ligaments were only loaded when the knee flexion angle was small.

Act.	PFJ	TFJ	ACL	PCL	MCL	LCL
Jump	4.5 ± 1.2 #	8.6 ± 2.1	0.7 ± 0.5	1.7 ± 1.1	0.6 ± 0.4	0.3 ± 0.1
Land	3.9 ± 1.2 ‡	9.2 ± 4.3	0.8 ± 0.7	1.5 ± 1.1	0.9 ± 0.7	0.3 ± 0.3
Jerk	5.1 ± 1.5 †#	10.6 ± 1.6	0.5 ± 0.4	2.4 ± 2.5	0.5 ± 0.2	0.1 ± 0.1
Catch	2.4 ± 1.1 *‡	7.9 ± 2.3	1.1 ± 0.8	1.0 ± 0.6	1.6 ± 1.2	0.1 ± 0.1

Table.1 Mean peak normalized forces (× BW ± SD) calculated during the four activities by the ICLLM including ligaments (* = $p<0.05$, when compared to jumping; † = $p<0.05$, when compared to landing; ‡ = $p<0.05$, when compared to jerk drive; # = $p<0.05$, when compared to jerk catch).

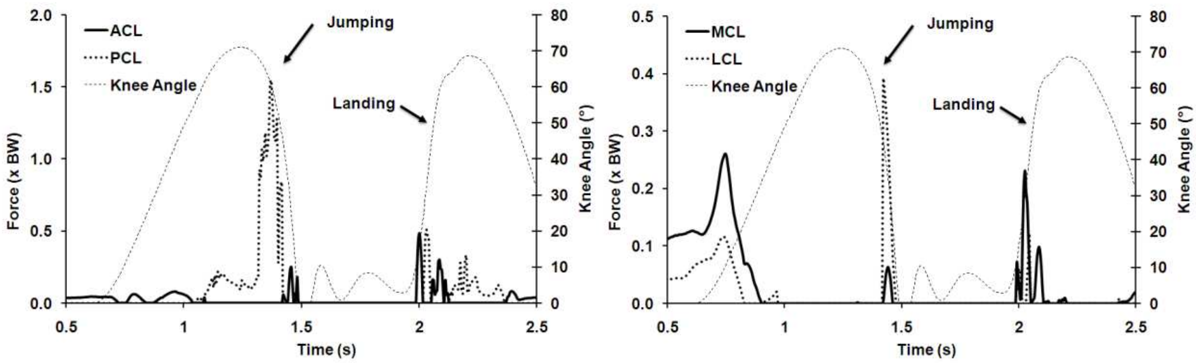

Fig.1 Ligament loading experienced by a typical subject during vertical jumping and landing.

DISCUSSION

Previous research that has evaluated the tensile strength of the cruciate ligaments suggests a failure limit of around 2 kN for the ACL of young healthy males [1] and 4.5 kN for the PCL [7]. This study suggests a mean peak ACL force during jumping, landing and jerking in the range of 410-900 N and a mean peak PCL force of 820-1970 N. These values are therefore well within the ranges that could potentially be borne by the cruciate ligaments although may be a little high given their proximity to the failure limits. The greater strength of the PCL is readily explainable by the differences in ligament loading seen during these activities. Similarly, the literature suggests that the MCL is stronger than the LCL, and the loading of the collateral ligaments in this study tends to support this contention.

The results of musculoskeletal modeling studies of internal knee forces have been reported by a number of groups however, the literature is hard to interpret due to the large range of values suggested. Despite this the joint forces found in this study are of a greater magnitude than those that are typically found in less demanding activities.

The ACL is a commonly injured structure during vertical jumping. This study suggests that the ACL is loaded immediately before takeoff and at the instant of landing, when the knee flexion angle is relatively small. The ACL is therefore likely to be at risk during these phases of a vertical jump. Similarly, the collateral ligaments are likely to be loaded at this time. There was variability in the ACL/PCL loading at the instant of landing, a fact that may contribute to the incidence of ACL injury. The behaviour of the collateral ligaments was consistent with that that would be expected based on the relationship between collateral ligament strain and knee flexion angle.

CONCLUSION

The extended posture of the knee during vertical jumping and landing, in combination with the expression of high forces, and the variability of these forces may contribute to the ACL injury risk during vertical jumping and landing.

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DOES LONG-TERM STRENGTH/POWER TRAINING COUNTERACT AGE-RELATED MUSCLE POWER DECLINE?

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INTRODUCTION

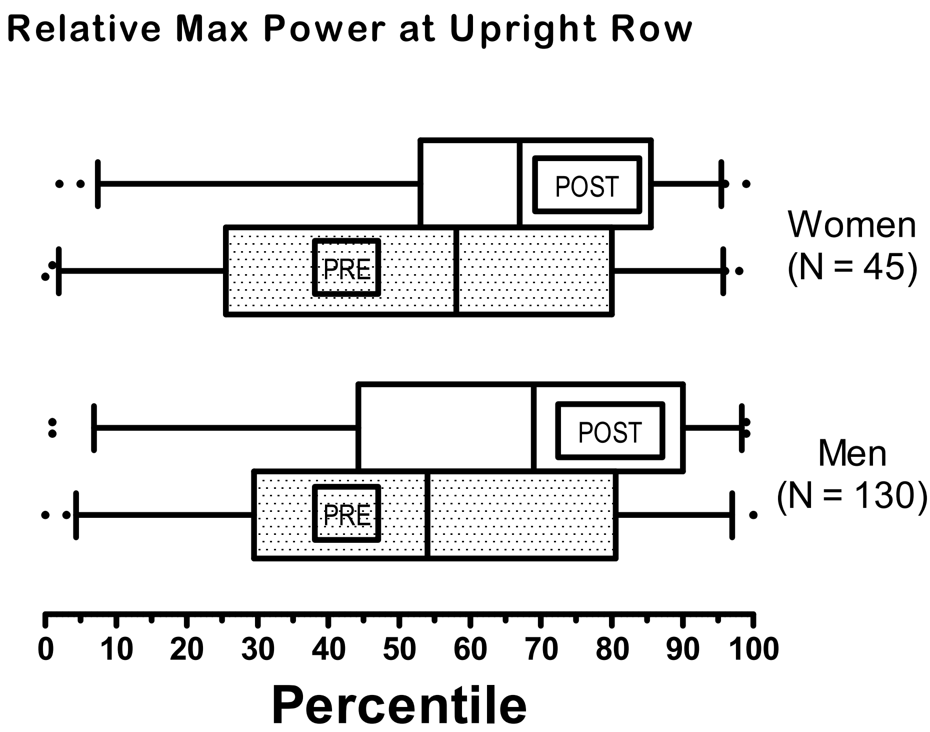
It is well-established that muscular strength and power are directly related to one's functional autonomy [1], following a natural decline with aging process [2], which may affect the ability to perform daily living activities. Evidences suggest that it is reasonable to expect that individualized-prescribed exercise interventions, including strength training, may attenuate or even reverse this trend. Notwithstanding, most of the scientific evidence favoring the health aspects of strength training are based in very short-term interventions, most of them limited to 8 or 12-week programs. So, our aim was to study if a long-term intervention with strength/power training was able to counteract age-related muscle power decline.

METHODS

Starting from 1735 subjects that were submitted to a complete medical-functional evaluation and that have participated in a medically-supervised exercise program (MEP) since 1994, a sample of 175 subjects (130 men) that fulfill several inclusion criteria – e.g. to have complete data available from two evaluations separated by five to 60 months between January 2002 and June 2010 – were retrospectively analyzed. The subjects (aged 63±11 years), most of them with known coronary artery disease, attended MEP three to six times/week, for about one hour of individually prescribed exercise per session, including 30-min of aerobic exercise at pre-determined heart rate zones (based on anaerobic threshold measured at maximal cardiopulmonary exercise testing), 10-15 strengthening exercises carried out as fast as possible in 2-3 sets of 5-8 reps and active and passive flexibility and balance exercises. The large majority of the subjects either remained attending the MEP or other exercise programs between the two evaluations. For the purpose of the current study, selected anthropometric variables and absolute and relative (body weight) maximum mean muscle powers (Max P) were obtained in the upright row exercise in a cable machine with a Fitrodyne device (Fitronic, Slovakia). Age-related intervention effects were also evaluated by determining the percentiles of those variables at the two evaluations, using as reference, data obtained from 2292 adults (age 18-91 years) (1576 men) in our laboratory with the same testing protocol. Linear regressions and one-tailed t-tests were carried out at 5% of significance level separately by gender.

RESULTS

Body weight did not change between evaluations – median time of 22 months - for both men (80.3±12 vs 80.0±12 kg; $p=0.23$) and women (67.6±15 vs 68.0±16 kg; $p=0.29$). Absolute and relative Max P were inversely related to age and increased similarly with exercise intervention for genders, with relative Max P values (Watts/kg) augmenting from 2.23 to 2.37 ($p<0.01$) for men and from 1.29 to 1.39 ($p=0.02$) for women. Considering the age-adjusted percentiles, the intervention effects were more also equally positive for both male – P49 to P62 ($p<0.01$) - and female subjects – P58 to P67 ($p<0.01$) -, with a median change of ± 10 percentiles. Linear regression analysis showed that time between evaluations, gender, age and body weight did not seem to significantly influence the magnitude of power gains, explaining less than 10-20% of the results variability. Notwithstanding, it should be noted that there was a large interindividual variability in the results.



DISCUSSION

Our large database of over 2,200 subjects indicates that relative Max P decreases at about 1%year for both genders. The present study shows that middle-aged subjects that attended a MEP and were submitted to a long-term exercise intervention, including strength/power training, present an increase of about 7% in relative Max P rather than an expected reduction (2%) in these values, when revaluated almost 2 years later in average. These results moved them from close to median to significantly above median values, when compared to peers at similar age. In addition, we were able to show that this beneficial effect occurs similarly for men and women.

CONCLUSION

Long-term exercise interventions, including strength/power exercises carried out as fast as possible at concentric phase, are able to counteract the age-related muscle power decline usually seen in middle-aged men and women. The present study characterizes an interesting role for strength/power training in a health-oriented lifetime perspective.

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EFFECTS OF RESISTANCE TRAINING ON MUSCLE STRENGTH AND POWER IN TRAINED YOUNG BASKETBALL PLAYERS

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INTRODUCTION

An important component of a comprehensive physical training program for young athletes is resistance training. Recent research [1-2] provides convincing evidence that adolescents enrolled in a properly designed resistance training program can significantly increase their muscle strength and power, above and beyond that expected as the result of growth and maturation. Moreover, some leading world fitness and health organizations [3-5] guidelines, review articles [6-7], and meta analysis [8-9] all state that strength training, if done properly, can be very beneficial for adolescents. The purpose of this study was to investigate the effects of enrolment in resistance training program (with free weight and machines) for young athletes that are already engaged in regular training process (that included calisthenics but not weight training or machines) for several years.

METHODS

The study participants (n=46) were young basketball players (15.8±0.8 yrs) without previous experience in organized resistance training. All subject were randomly assigned into experimental (n=23) and control group (n=23). The experimental group performed a 12 week, whole-body resistance-training. They participated in two training sessions every week during the period of twelve weeks (total of 24 training sessions). Strength exercises were performed for 9 exercises per session, with 2-3 exercises chosen to isolate the major muscle groups as follows: chest, upper back, shoulders, arms, abdomen, and legs, with 2-3 sets per exercise, 8-12 repetitions per set, and around 90 seconds of recovery time between sets. Subjects were instructed to complete the prescribed number of repetitions or until 10-12 repetitions with correct technique; if a greater number of repetitions was achieved, the weight was increased during the following session to permit progressive adaptation. During one training week (2 sessions) all major muscle group were exercised only once. Each session lasted approximately 60-70 minutes. Subjects where tested on bench press for 1 repetition maximum - 1RM and parameters for strength and power at their 30, 40, 50 & 60 % of 1RM. A device to measure muscle power (FitroDyne; Fitronic, Bratislava, Slovakia) was used to determine and evaluate upper-body muscular power for each subject.

RESULTS

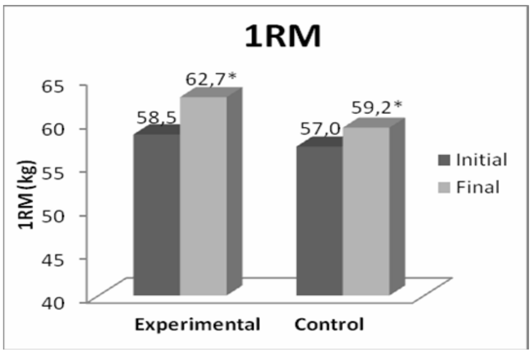

Fig.1 1RM measured before and after 12 weeks resistance training. Pre < post training: * p<0.05.

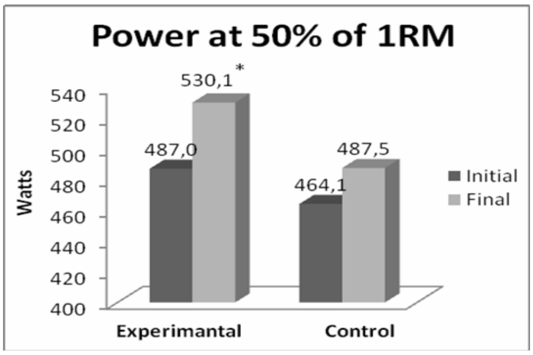

Fig. 2 Muscle power measured at 50% of 1RM in bench press. Pre < post training: * p<0.05.

The increase were observed in both groups. Strength, measured as 1RM, increased by 4,3 kg in absolute terms and by 7,2% in relative terms in the experimental group, whereas the control group improved strength by 2,2 kg or 3,8%, respectively (Fig. 1). Although both groups increased 1RM, the magnitude of increase was significantly different between them ($P < 0.05$). A significant differences ($F = 3.44$; $P<0.04$) in strength and power measurements between groups was observed only in the testing at 50% of 1RM (Fig. 2). No significant changes occurred in the three other resistances (30, 40 and 60% of 1RM).

DISCUSSION

Experimental program induced statistically significant changes in some force and power parameters. However, the resistance training program induced far less changes than previously observed [1-2]. In short-term (8 to 20 weeks) resistance training programs, the expected progress in strength in children and adolescents is around 30% [3]. Falk and Tenenbaum meta-analysis [9] found that gains in muscle strength were approximately 13-30% greater than that which would be expected to result from growth and maturation. Some authors found even greater strength gains (from 55 to 74%) after 8 weeks of resistance training [10,11]. Our study found gains around 3% greater than that which would be expected to result from growth and maturation. However, most of the previously cited studies used untrained or moderately trained children and adolescents as subjects, while we used subjects that are already in long term training process. In addition, the largest increase in strength and power were seen at 50% of 1RM. Early training studies using untrained individuals reported that the optimal load for improving power was approximately 30% of 1 repetition maximum [12]. Later studies using the individuals who were experienced in explosive exercises reported that loads between 40 and 70% of 1RM were most effective in power production improvements [13-14].

CONCLUSION

The primary purpose of this study was to examine the influence of added resistance training in a regular training process in trained young athletes. Resistance training program induced far less changes than previously observed, probably because the subjects were already involved in training process for several years and were already well adapted. Another factor that influenced lower changes may be found in the intensity of resistance training program. Results from our study, with the greatest improvement at the 50% of 1RM, suggest that with trained subjects, maximum power gains should be expected around 50% of 1RM.

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TWELVE WEEKS OF STRENGTH AND ENDURANCE TRAINING EFFECTS ON ANAEROBIC CAPACITY AND CARDIORESPIRATORY ENDURANCE IN JUDOKAS

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INTRODUCTION

The main characteristic of a judo combat is the intermittence, on account of interruptions and alterations of the intensity of the efforts during the combat. Studies about the time structure in a 5-min judo match demonstrated that the combat and rest periods have values around 15 to 30-s and 10-s, respectively [1]. These time characteristics taxes both the aerobic and the anaerobic systems. The anaerobic system provides the short, quick, all-out bursts of maximal power during the match, while the aerobic system contributes to the athlete's ability to sustain effort for the duration of the combat and to recover during the brief periods of rest or reduced effort [2,3]. In a high level competition judokas perform 5–7 matches in the same day in order to classify among the best five competitors. The successful combination of training depends on many factors such as the athlete's genetic potential, length of training experience, current physical preparation form, intensity and extent of training, optimal periodization, nutritioN, etc. The competition performance capacity in judo is dependent on several factors among which the physiologic ones represent only one aspect. As a consequence, a strong connection between physiologic adaptations to training, combination of training, and performance is very difficult to establish.

METHODS

A total number of 14 male judokas, with several-year-lasting sport experience, participated in the investigation. They were divided into two groups: experimental (E, n=7) and control (C, n=7). Over 12 weeks, subjects from E group were included into specially designed training program composed of concurrent strength and endurance training and perfecting of specific judo techniques. Subjects from C group were included into the same strength training and perfecting of specific judo techniques, but did not have any endurance training. The whole investigation was carried out during preparatory period, before the start of competition period. The 12-week whole-body strength training was carried out, under supervision, three times per week. The program included three to five exercises for the main muscle groups of the body. Mainly, machine exercises were used throughout the training period. The intensity ranged from 60 to 85% of the 1RM. The number of sets in each exercise increased and the number of repetitions decreased during the training program. Endurance training consisted of running twice a week. All the training sessions were supervised and a heart rate monitor was used. Subjects were engaged in a 30 min training session divided into four loading intervals: 10 min under aerobic threshold, 5 min between aerobic-anaerobic thresholds, 5 min above the anaerobic threshold and again 10 min under aerobic threshold. The focus of training was to improve maximal endurance in a 30-min session. The anaerobic capacity (AnC) parameters (peak power and mean power) were determined by the "all-out" 30-s Wingate anaerobic test (WanT) with arm cycle ergometer (Monark, Sweden). VO_{2peak} was estimated by a method of extrapolation after a standardized submaximal test on the leg cycle ergometer and arm cycle ergometer along with telemetric monitoring of heart function (Polar, Finland). The testing was carried out at least 24 h prior the execution of the WanT. The percentage of fat mass was measured by bioelectrical impedance analysis (BF300, Omron, Japan). Field test The special judo fitness test (SJFT) (Franchini et al. 1998) was performed in a training gym, at least 6 h after Wingate test. Basically, during the upper body WanT, power is calculated constantly, but the movement used (arm cranking) is not specific to judo actions. In the SJFT, the number of throws during an intermittent judo task is measured, being less precise than the WanT, but more specific to judo.

RESULTS

The results are presented in table 1 and 2.

Table 1. Subject physical characteristics along 12-week experimental training period

	E ($n = 7$)	C ($n = 7$)
Age (years)	23 ± 1.5	22 ± 1.8
Sport experience (years)	13 ± 4.2	12 ± 3.7
Body height (cm)	178.4 ± 6.18	176.9 ± 7.44
Body weight (kg)		
Pre-training	75.3 ± 11.2	74.1 ± 10.5
Post-training	72.6 ± 9.9 *	72.8 ± 9.7
Body fat content (%)		
Pre-training	9.08 ± 3.86	8.82 ± 4.08
Post-training	7.86 ± 4.04 *	8.4 ± 3.64

Values are means ± SD; * significant difference ($p < 0.05$) from corresponding pre-training value; E, experimental group; C, control group.

Table 2. Subjects performance characteristics along 12-week experimental training period

	E ($n = 7$)	C ($n = 7$)
Peak power ($W \cdot kg^{-1}$) on arm ergometer		
Pre-training	9.82 ± 1.66	9.44 ± 1.82
Post-training	11.78 ± 1.8 *	12.34 ± 1.94 *
Mean power ($W \cdot kg^{-1}$) on arm ergometer		
Pre-training	7.16 ± 0.96	7.31 ± 1.08
Post-training	8.54 ± 1.1 *	8.98± 1.22 *
VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$) on arm ergometer		
Pre-training	46.52 ± 6.67	48.32 ± 6.22
Post-training	50.86 ± 5.92 *	47.66 ± 5.84
VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$) on leg ergometer		
Pre-training	51.24 ± 7.38	50.28 ± 6.6
Post-training	54.58 ± 6.96 *	51.98 ± 7.08
SJFT index		
Pre-training	15.86 ± 2.32	15.41 ± 2.08
Post-training	13.24 ± 1.75 *	13.58 ±1.91 *

Values are means ± SD; * significant difference ($p < 0.05$) from corresponding pre-training value. E, experimental group; C, control group.

DISCUSSION

The results showed that in the C group subjects there was a significant increase in the values of AnC parameters, while VO_{2peak} value did not change significantly after 12 weeks. A methodical plan aimed to improve the performance of specific judo techniques, performed under the supervision of experienced trainers, resulted in a greater number of throws made during SJFT. With a lower value of the heart frequency, the overall SJFT index was lower, and the achievement was better. In the E group subjects, 12-weeks' concurrent training resulted in a significant increase in the values of AnC parameters. The comparison of results obtained between groups showed that at the beginning and end of the investigation there were no significant differences in the examined parameters. However, the values of AnC parameters were higher in the C group subjects after 12 weeks. The above mentioned points out that the concurrent training resulted in somewhat smaller effects of strength training in the E group subjects. VO_{2peak} values were significantly higher after 12-weeks' training, pointing out to the effectiveness of concurrent training on the development of endurance. SJFT index values were statistically significantly lower after 12-weeks' preparatory period. Such a result is attributed to the improvement in performances of specific judo techniques, the same as in the C group subjects, as well as to a significantly lower heart frequency during the test which is considered to be another effect of endurance training. After both 12 weeks' training programs we noticed significant changes in body composition of subjects involved in study, decreased of body weight and body fat content. A smaller percentage of fatty tissue in elite judokas is thought to enable better metabolic adaptation to different technical-tactical demands during the match.

CONCLUSION

The results obtained suggest that concurrently performed training for strength and endurance induces the increase in anaerobic power and maximal oxygen uptake in experienced judokas. Although we tested a small group of athletes, we suggest that specific judo training programs should be planned to include exercises that stimulate anaerobic and aerobic metabolism at the same time. Future research may investigate different combination of concurrent training for functionally effective judo training, in an attempt to establish a more stronger connection between physiologic abilities, technical skills and competitive success in judo.

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EFFECT OF SERIAL STRETCH LOADING ON SELECTED PARAMETERS OF STRENGTH CAPABILITIES

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INTRODUCTION

It has been well established that different protocols and methods of strength training contribute to different outcomes. Serial stretch loading has been applied in an attempt to gain greater neuromuscular performance, which is of practical relevance for both, healthy adults as well as subjects with insufficient neuromuscular functions [2]. In addition to enhancement of muscular performance, serial stretch loading also play an important role in joint stability and injury prevention [2, 7]. Previous studies dealing with the effect of serial stretch loading on strength parameters have brought contradictory findings, presumably due to the application of largely different training characteristics (volume, intensity) as well as insufficient specification of stretch loading stimuli [2, 6]. Therefore, the purpose of this study was to examine the influence of an 8-week strengthening program based on precisely defined serial stretch loading protocol on selected parameters of strength capabilities.

METHODS

Twenty nine young male sport students were enrolled for this study. They were moderately physically active at least three times, but no more than 5 times a week. The subjects were randomly divided in an experimental group (SSL) (age 23.1 ± 2.72 years, height 183 ± 6.28 cm, weight 76.7 ± 10.3 kg) and a control group (ISOK) (age 22.6 ± 3.94 years, height 181 ± 6.88 cm, weight 80.1 ± 10.3 kg). Both groups underwent strength training on a novel, computer controlled, linear motor powered leg press dynamometer using two different training protocols.

SSL was exposed to so called serial stretch loading mode, where constant velocity of pedals is alternated by short periods of movement at different velocities in order to produce short force peaks. These have been achieved by short counter movements during the concentric contraction and acceleration segments during the eccentric phase. In present study concentric velocity of the 0.3 $m.s^{-1}$ was temporarily replaced (after every 2 cm) by short 0.5 mm counter movement at 0.2 $m.s^{-1}$. In eccentric phase velocity of 0.2 $m.s^{-1}$ was alternated after every 2 cm by short 5 mm segments of higher velocity (0.7 $m.s^{-1}$). Such a setting yielded a frequency of the force peaks of 9 Hz and 8.5 Hz in the concentric and eccentric phase respectively [4]. The training session of the SSL consisted of 6 sets with 6 repetitions each, performed with maximal effort.

The training of ISOK consisted of leg press exercises in the isokinetic mode, also performed with maximal effort. The velocity was 0.3 $m.s^{-1}$ in the concentric phase and 0.2 $m.s^{-1}$ in the eccentric one. In order to compensate difference in the contraction time caused by missing changes of velocity in isokinetic mode, the number of repetitions was increased to eight. The number of sets (6) and the resting interval between sets (2 minutes) were identical with SSL group. The program consisting of 3 sessions a week was applied for an 8-week period. Both groups underwent tests of strength capabilities before and after eight weeks of strength training. Subjects performed tests of maximal isometric unilateral leg extension (MVC), squat jump and 30-m acceleration running test. From MVC, peak force and rate of force development from time segment 0 – 50 ms were obtained. Unpaired student´s t-test was used to evaluate differences between the groups ($p < 0.05$). The mean values before and after intervention in both groups were compared with the use of two-tailed Student´s t-test ($p < 0.05$).

RESULTS

The maximal isometric unilateral leg extension showed in both groups SSL and ISOK highly significant ($p < 0.01$) improvement from 3146 ± 766 N to 4658 ± 1813 N (48.1 %) and from 3565 ± 898 N to 4450 ± 1377 N (24.8 %) respectively. Rate of force development in time segment 0 – 50 ms increased significantly ($p < 0.001$) only in the SSL group from 22.4 ± 5.44 N/ms before training to 29.1 ± 8.87 N/ms after training (30.2 %). In the ISOK group, the rate of force development in the time segment 0 – 50 ms increased from 24.5 ± 6.45 N/ms to 26.1 ± 8.56 N/ms (6.6%) without reaching statistical significance. The height in squat jump test increased significantly ($p < 0.005$) in the SSL group from 0.439 ± 0.057 m before training to 0.471 ± 0.050 m after training (7.40 %) whereas no significant increase was found in the ISOK group. The performance in 30-m acceleration running test increased significantly ($p < 0.05$) in the SSL group from 4.16 ± 0.11 s before training to 4.11 ± 0.09 s post training by 1.3%. But in the ISOK group the 30-m acceleration running test did not show any significant differences.

DISCUSSION

The pre compared to the post test analysis performed for SSL as well as ISOK demonstrated significant improvement of the MVC in both groups without significant differences between the groups, which is in contrast to reports by Benn [2]. However, significantly higher gains of another parameter of strength capabilities, rate of force development, were observed only after serial stretch stimulation. Furthermore, there were significant differences only in SSL in other functional parameters tested, namely height of the jump and 30-m acceleration test. These findings support the previous investigations of Hamar [5], Delecluse [3] and Paradisis [8]. The improvement of the explosive force only in SSL can be ascribed to amelioration of neuroregulatory mechanism (increased rate of motoneuron firing frequency and intermuscular coordination of agonist and antagonist) [3, 9], and theoretically also to the increase of the size of type II muscle fibers. Statistically significant gains of explosive force parameters, specific to the SSL, are of substantial practical relevance for both, elite athletes and subjects with impaired muscle function. In most of the sports limited time for force production determines the magnitude of acceleration and essentially influences the movement of an athlete´s body or equipment. Higher rate of force development enables to produce higher force impulse, which can be mirrored in better sport performance. Rate of force development has recently been associated also with capacity to maintain postural control as well as ability to recover balance after stumbling. This may be of special importance in elderly population, in which reverting of age related deterioration of RFD may reduce the risk of falling and related medical complications [1].

CONCLUSION

In summary, findings of this study showed that 8-weeks of systematic application of mechanical serial stretch stimuli in young men improves MVC, explosive force as well as acceleration performance. Traditional isokinetic strength training leads to improvement of MVC, but does not enhance either the explosive force or the acceleration performance.

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Present study was supported by the European regional development fund (ERDF, Interreg IIIa).

COMPARING THE EFFECTS OF DIFFERENT VIBRATION EXERCISES BETWEEN-SETS ON UPPER BODY PERFORMANCE IN ELITE JUDO ATHLETES

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INTRODUCTION

The aim of judo athletes is to wrestle their opponent to the ground or to obtain control during groundwork. Strength and muscle power are necessary for the effective application of techniques [3]. For efficient and effective training, it is of extreme importance to understand the interaction among training variables, which might include the intensity, number of sets, exercise modality, velocity of muscle action, and rest method between sets [1]. The rest interval between sets is an important variable that affects both acute responses and chronic adaptations to resistance exercise programs [2]. In this sense, a study was recently published showing that power output in the squat exercise was greater following a short bout of vibration stimulus (30 s) [5]. This study examined a unique application of vibration as a pre-exercise for the back squat in an attempt to increase rate of force production during the squat. However, to our knowledge, no previous studies have measured the effects of different vibration recovery strategies via feet vs. hands on neuromuscular performance of upper-limb muscles. Thus, this study aimed to analyze the effects of different vibration recovery strategies via feet or hands on the number of repetitions performed, mean velocity and peak velocity during three sets of bench press exercise in elite judoists.

METHODS

Nine elite judoists (6 males and 3 females) with 9.3 (±1.73) years of training experience in judo participated in the study. The subjects' mean (±SD) age, height, body mass and bench press 1RM were 17.1 (±1.7) years, 163.2 (±8.2) cm, 60.8 (±8.6) kg, and 69.9 (±19.4) kg, respectively. Data collection took place over a period of 3 weeks with 2 testing sessions each week. First three sessions were used to familiarize subjects with testing procedures and to assess the subjects' one-repetition maximum (1RM). During each of the next 3 testing sessions, 3 sets of the bench press were performed at 60% of 1RM, leading to failure and allowing a 180 s rest period between sets. During the rest period, one of the three conditions designed was performed: 150 s rest plus 30 s push-up vibration exercise (Push-up; [frequency: 50 Hz; peak-to-peak amplitude: 2.68 mm]), 150 s rest plus 30 s squat vibration exercise (Squat; [frequency: 50 Hz; peak-to-peak amplitude: 2.68 mm]) and 180 s only rest (Passive). The vertical vibration platform used was Fitvibe Excel (Fitvibe, GymnaUniphy NV, Bilzen, Belgium). A counterbalance procedure was used to determine the resting strategy order for each testing session.

RESULTS

Regarding the total volume of repetitions completed over two sets (second & third set) (see Fig. 1), the one-factor ANOVA revealed a significant rest strategy effect (p <0.01). Post-hoc analysis pointed out that total number of repetitions was significantly higher in squat condition compared to passive condition (12.2%; p<0.05) and push-up condition (36.7%; p <0.001). Moreover, total number of repetitions in push-up condition was significantly lower than passive-condition (24.36%: p <0.01). The results of the two-factor ANOVA revealed for mean and peak velocity only a significant set main effect (P<0.05) but no interaction effect. The mean and peak velocity during set 1 was significantly higher than during both set 2 and 3.

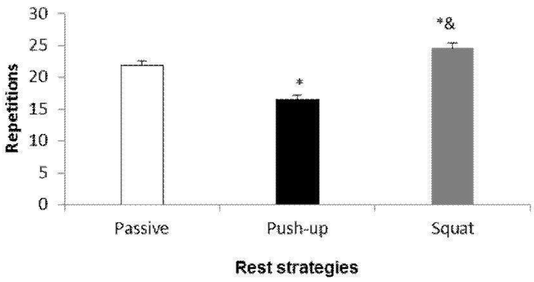

Fig. 1. The total volume of repetitions completed over the last two sets (Mean ± SE). *Significantly different from passive strategy. &Significantly different from Push-up strategy.

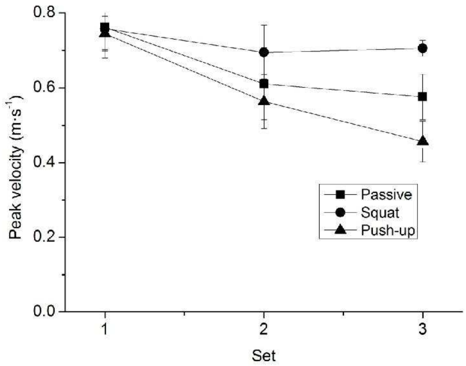

Fig. 2. Peak velocity (Mean ± SE) per set during each recovery strategy.

DISCUSSION

The major finding of this study was that elite judo athletes increased their total volume of repetitions completed over 2 sets (last two sets) to volitional exhaustion at 60% 1RM after squat WBV rest strategies compared with all other rest strategies. On the contrary, mean and peak velocities were not affected by WBV. In the present study, the individual kinematic profile was variable and the sample size was small, therefore the lack of statistical significance could be due to a *Type II* error.

An important point is that the results of the current study may not apply push-up WBV immediately before a set of bench press. Push-up WBV immediately before the bench press exercise could induce too much fatigue. According to Miranda et al [4] prior research demonstrated greater fatigue resistance for lower-body exercises vs. the upper-body exercises. The facilitatory effects of vibration in healthy subjects may be able to influence the excitatory state of the peripheral and central structures of the brain, which could facilitate subsequent voluntary movements. Thus, this could explain how a vibration stimuli applied mainly to the lower limb (such as the WBV used in the present study) could affect upper-limb muscle performance. However, no motor cortex excitability measures were taken in this study, and little evidence exists to support this hypothesis.

CONCLUSION

These data suggest that a vibration stimulus applied to the feet (30s, 50 Hz and 2.68 mm), between sets, can result in positive improvements in upper body resistance exercise performance. Strength and conditioning professionals should consider the use of WBV between sets for resistance training exercises, such as the bench press, when prescribing programs for strength development.

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BILATERAL ISOKINETIC STRENGTH PROFILE OF KNEE FLEXORS AND EXTENSORS IN SOCCER PLAYERS

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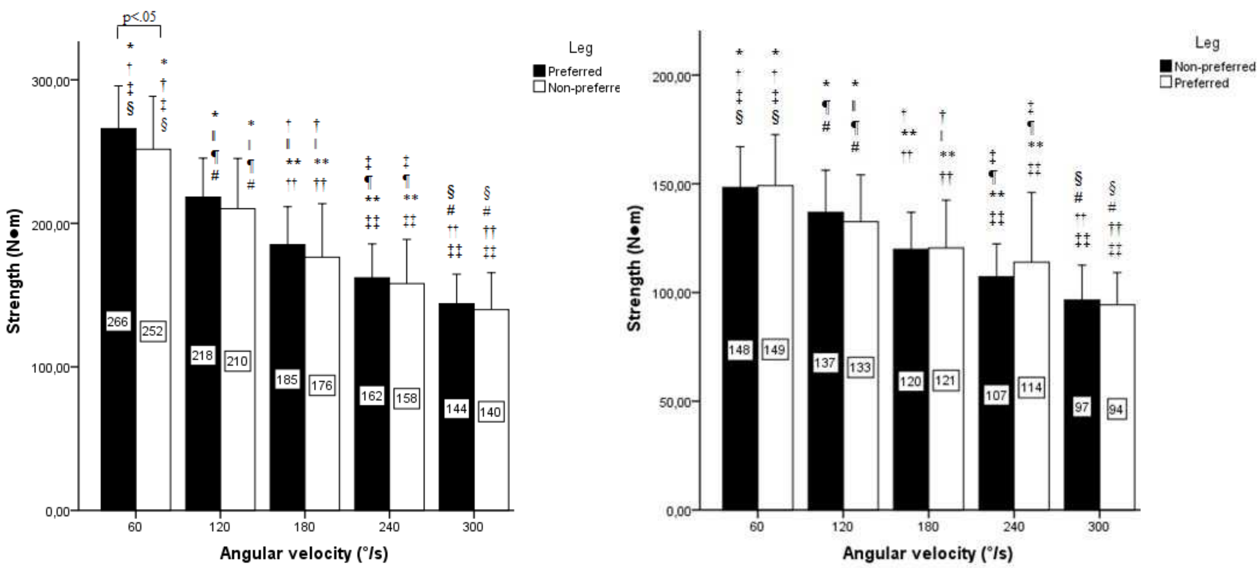
INTRODUCTION

Isokinetic assessment of knee flexors and extensors is extensively used to monitor strength development and strength imbalances in soccer players. Since the game of soccer frequently involves one-sided activities such as kicking, tackling and passing asymmetries in muscle strength between both legs are possible.The study by Lehance et al. (2009) reported that up to 56% of the players are at risk of muscle strength imbalances of knee flexors or extensors. The authors present a higher proportion of muscle strength imbalances in young soccer players in comparison to senior players. Croisier et al. (2005) indicate that the isokinetic strength assessment before the start of the season enables identification of strength indicators as predictors of possible muscle injury. Knapik et al. (1991) state that the athletes with muscle strength imbalances higher than 15% at bilateral comparison of extremities had 2.6-times higher frequency of injuries when compared to athletes who had this difference lower than 15%. The aim of the study was to determine the profile of isokinetic strength of elite young soccer players and to determine the ratio of muscle strength between knee extensors and their bilateral strength imbalances.

METHODS

The sample was composed of soccer players of the highest junior league level (n=12, age 17.5±1.5 years, height 174±8.5 cm, weight 75.6±13.1 kg). Assessment was performed on the isokinetic dynamometer Cybex Humac Norm (Cybex NORM ®, Humac, CA, USA). We evaluated: maximum peak muscle torque of knee extensors (PT_E) and flexors (PT_F) in both legs. Strength parameters were obtained in the concentric contraction at angular velocities of 60, 120, 180, 240 and 300°·s^{-1}. Significant differences were evaluated by the RM ANOVA (1x5) and *post-hoc* Bonferonni's test. Statistical significance was set at $p<0.05$.

RESULTS



(a) (b)

Fig.1 Peak muscle torque of knee extensors (a) and flexors (b).

Legend: significant difference between velocities: *–60 vs. 120°·s^{-1}, †–60 vs. 180°·s^{-1}, ‡–60 vs. 240°·s^{-1}, §–60 vs. 300°·s^{-1}, ‖–120 vs. 180°·s^{-1}, ¶–120 vs. 240°·s^{-1}, #–120 vs. 300°·s^{-1}, **–180 vs. 240°·s^{-1}, ††–180 vs. 300°·s^{-1}, ‡‡–240 vs. 300°·s^{-1}.

The muscle strength of knee extensors significantly decreased with increasing velocity in preferred ($F_{1.45;\ 15.93}$=520.11, p<0.05) and non-preferred lower extremity ($F_{4;\ 11}$=311.03, p<0.05). *Post-hoc* test showed a significantly different level of all mutually compared results of muscle strength exerted at different velocities of movement (Fig.1). PT_E in the preferred leg was higher at all velocities. However, We have found statistically significant difference only at the lowest velocity ($t_{(11)}$=3.05, p<0.05). PT_F was significantly decreased with increasing velocity in both the preferred and non-preferred legs ($F_{1.75;\ 19.23}$=74.82, p<0.05, and $F_{2.37;\ 26.05}$=119.42, p<0.05). *Post-hoc* test showed significant differences in PT at all mutually compared velocities in both legs with the exception of the difference between muscle strength exerted at 120 vs. 180°·s^{-1} in the dominant lower extremity (p>0.05). Differences between legs was not revealed (p>0.05).

DISCUSSION

Knee extensor strength in the preferred leg was PT_{E60}=260.0±29.8 N·m at the lowest velocity. The lower value PT_{E60}=231.7±30.4 N·m in elite junior soccer players was reported by Lehance et al. (2009). At the highest velocity, PT_{E300} strength achieved only 54% of PT_{E60}. The level of PT_E and PT_F declined with increasing velocity in both legs. PT_E was higher in the preferred leg compared to the non-preferred leg at each velocity. It is in line with the results of Rahnama et al. (2005). We found out significant difference between legs in PT_{E60}. Rahnama et al. (2005) did not find any significant differences in PT_E between the preferred and non-preferred legs at three different velocities (60, 120, 300 °·s^{-1}) in elite soccer players. Significant differences in bilateral comparison of knee flexors strength was not revealed. Rahnama et al. (2005) present differences in PT_{F120} between the preferred and non-preferred legs. At higher velocities our participants reached higher values in the non-preferred leg. The same result was found by Gür et al. (1999) in young players. Rahnama et al. (2005) state a significant difference in PT_{F120} in elite players in favor of the non-preferred leg, which exerted more muscle strength by 5.6% compared to the preferred leg. These findings are contrary to study by Kellis et al. (2001), which found higher muscle strength of the preferred leg at higher velocities, as well.

CONCLUSION

Measurements of isokinetic muscle strength provide an objective approach to diagnostics and simpler quantification of muscle strength and its parameters in soccer players. Testing on an isokinetic dynamometer enables the monitoring of strength manifestation in the concentric contraction at a constant velocity, which allows intra- and interindividual comparisons when values are standardized. The important of assessment strength indicators in young soccer players has followed reasons (Lehance et al., 2009): to ascertain the absence of muscle strength imbalances between the extremities (or that imbalances are within the limits), to ensure that muscle strength is well balanced between the knee flexors and extensors and finally, that a soccer player with his level of strength abilities meets the standards (norms) according to his age and performance level.

This project was supported by MSM 0021620864 and GAČR 406/08/1514

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INFLUENCE OF RESISTANCE TRAINING ON CARDIORESPIRATORY ENDURANCE IN YOUNG ATHLETES

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INTRODUCTION

Properly planned physical training program aims to improve a variety of physiological parameters such as maximal oxygen uptake (VO_{2max}) and different muscle capabilities (strength, power and endurance). An important component of a comprehensive physical training program for young athletes is resistance training. It's considered safe and effective in young athletes, recommended by expert and leading field organizations, but if incorporated in a total training program that include basketball aerobic drills, it may not be the case. Some athletes are still afraid that participation in resistance training program may compromise their endurance capabilities. The reason for this is possible antagonistic skeletal muscle adaptation when both types of training are done concurrently. In addition to muscle hypertrophy that is usually caused by increase in myofibrillar protein content, resistance training may also induce decrease in mitochondrial volume density and capillary density [1,2]. The present study investigates the influence of added resistance training on cardiorespiratory endurance in young trained basketball athletes.

METHODS

The study participants (n=46) were young basketball players (15.8±0.8 yrs) without previous experience in organized resistance training. All subject were randomly assigned into experimental (n=23) and control group (n=23). The experimental group performed a 12 week, whole-body resistance-training. They participated in two training sessions every week during the period of twelve weeks (total of 24 training sessions). Strength exercises were performed for 9 exercises per session, with 2-3 exercises chosen to isolate the major muscle groups as follows: chest, upper back, shoulders, arms, abdomen, and legs, with 2-3 sets per exercise, 8-12 repetitions per set, and around 90 seconds of recovery time between sets. During one training week (2 sessions) all major muscle group were exercised only once. Each session lasted approximately 60-70 minutes. Subjects where tested on bench press for 1 repetition maximum - 1RM and parameters for strength and power at their 30, 40, 50 & 60 % of 1RM. A device to measure muscle power (FitroDyne; Fitronic, Bratislava, Slovakia) was used to determine and evaluate upper-body muscular power for each subject.Cardiorespiratory endurance was assessed 24-48 hours after the muscular strength test. The investigation protocol consisted of VO_{2max} measurement during standardized maximal tests on a leg cycle ergometer (Kettler, Germany). During each test, participants breathed through a two-way mouthpiece (Hans Rudolph, Kansas City, USA). Oxygen uptake and related gas exchange measures were determined continuously on a 15 s basis using an automated cardiopulmonary exercise system (FitMate Med, Cosmed, Italy). Respiratory variables (ventilation, respiratory rate, forced expiratory volume in 1 s, and maximum voluntary ventilation) and heart rate (Polar Electro Oy, Kempele, Finland) were recorded at the end of each minute.

RESULTS

Strength, measured as 1RM, increased by 4,3 kg in absolute terms and by 7,2% in relative terms in the experimental group, whereas the control group improved strength by 2,2 kg or 3,8%, respectively (Fig. 1). Although both groups increased 1RM, the magnitude of increase was significantly different between them ($P<0.05$). A significant differences ($F=3.44$; $P<0,05$) in strength and power measurements between groups was observed only in the testing at 50% of

1RM. No significant changes occurred in the three other resistances (30, 40 and 60% of 1RM). No significant changes took place in the VO_{2max} values during the 12-week training period. Also, no significant changes occurred in the maximal heart rate (experimental group: 197beats/min±6 pre vs. and 196±7 post) during the 12-week training period.

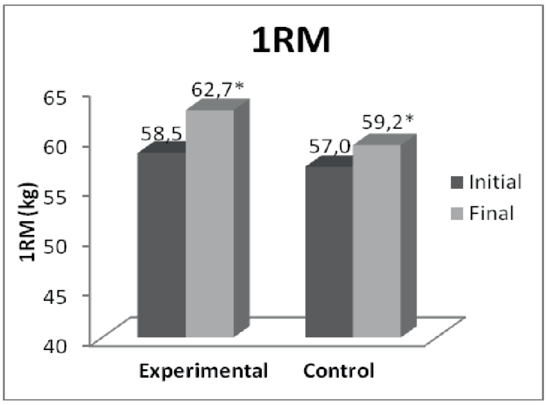

Fig.1 1RM measured before and after 12 weeks resistance training. Pre < post training: * p<0.05.

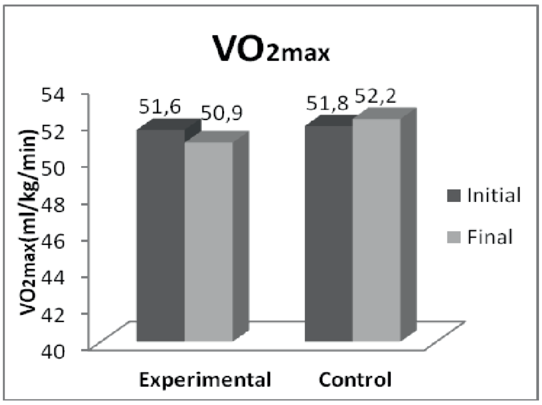

Fig. 2 VO_{2max} before and after the resistance training program.

DISCUSSION

Primary purpose of this study was to examine the influence of added resistance training in a regular training process with predominantly aerobic drills. Our specially designed 12-week resistance training program incorporated in a comprehensive training program, did not significantly change aerobic performance capacity, since VO_{2max} remained unchanged. Although strength training may lead to peripheral changes that could be considered antagonistic to aerobic power development and may lead to reductions in muscle mitochondria, capillary, and aerobic enzymes, some studies [3,4] found significant increases of both aerobic and strength performance following concurrent training. However, all of these studies used previously untrained subjects. The rare studies [5,6] that used trained adult athletes as subjects, substituted the part of conditioning program dedicated to endurance training with explosive strength training. This substitution led to increased performances, but endurance capacity was not compromised and VO_{2max} did not change significantly. The "interference effect" in strength development and muscle hypertrophy when strength and endurance training are performed concurrently can be expected when the overall frequency and/or volume levels of the training are higher then an individual system can adapt to. These finding are important for young athletes for whom both aerobic and anaerobic capacities are crucial for performance.

CONCLUSION

The present findings have some practical relevance too, since maximal aerobic performance in young athletes will not be compromised by using a frequency as low as twice per week for resistance training, when the training program meets the requirements of progressiveness and individualization, and if it is based on the true monitoring of each training session.

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THE OPTIMAL LOAD FOR THE THROWER´S DYNAMIC EFFORT STRENGTH TRAINING DETERMINED BY USAGE OF DIFFERENT METHODS

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INTRODUCTION

The purpose of the dynamic effort strength training is to develop or to maintain the maximal power output with an optimal load [5,6]. Such a load is often expressed in a percentage of one repetition maximum and it creates optimal conditions for the production of maximal power output during a lift. Currently, there is no conformity in opinion on the amount of the relative optimal load for a countermovement squat jump (CMJ) exercise [1,3]. Cormie et al. [1] supposes that discrepancies in the optimal load values found in contemporary literature can be caused among others by different methods of power output measurement. The purpose of the study is to determine an optimal load for dynamic effort strength training of a Czech elite thrower by means of the method used in training practice (BKM) and laboratory method (COGM), which is regarded as a validity criterion from the biomechanical point of view.

METHODS

A 23-year old thrower participated on this study. His personal record in discus throwing is 54.50 m and in shot putting 14.99 m. This case was a part of a research into 10 throwers where our thrower exhibited the highest maximal strength and power output. His one repetition maximum of a countermovement squat was 180 kg, height 184 cm, weight 112 kg out of which 22% was fat. Testing was completed after an entire strength and power training cycle. The session involved the measurement of power output for the countermovement squat jump while systematically increasing the load 0, 10, 30, 50, 70 and 90% of one repetition maximum. There was a 3-minute rest between every single trial. Three-dimensional kinematic data were collected at 247 Hz using a seven camera motion capture system (Qualisys Oqus, Sweden). Force plate (Kistler 9281CA, Switzerland) embedded in the floor, was sampling at 988 Hz and was used to measure ground reaction force during the lift. Power testing was carried out using free weight form CMJ techniques with a minimum of 90 degrees in a knee angle. Retro reflective markers were attached to the whole body according to the recommendation of the C-motion Company (C-motion, Rockville, MD, USA) as well as terminal points and medial point of the barbell. Marker data were processed using Visual 3D software (C-motion, Rockville, MD, USA). All extremity segments were modeled as a frustum of right circular cones whilst the torso, pelvis and barbell were modelled as a cylinder and the head as a right circular ellipsoid of revolution according to Hanavan [2]. Then two data analysis methods were used. Using the Barbell kinematics method (BKM) a power output P in the vertical direction was assessed only on the basis of known barbell movement speed v in time t, weight of the barbell and load m as follows:

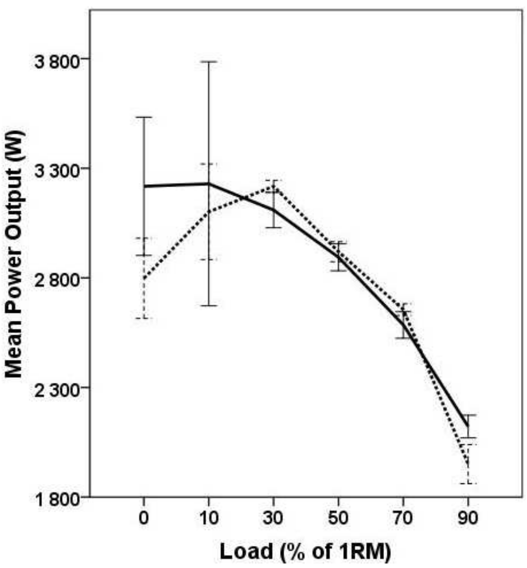
$$P = m(\mathrm{d}v/\mathrm{d}t + g)v$$

where g is the gravity acceleration. Using the centre of the gravity kinematic-kinetic method (COGM) the mechanical power was calculated as a product of an imaginary vertical force F_z (magnitude of Ground reaction force) and the vertical velocity of the center of gravity v_{zcg} (system body segments and barbell derived from V3D software)

$$P = F_z v_{zcg}$$

The rotational movement of the lower extremity segments was neglected. Thus the mean power and standard deviation for each load was determined from the complete concentric phase of two jumps. To evaluate the differences in power output determined by means of the COGM method and the BKM method, an effect of size (ES) was used.

RESULTS



The optimal load for maximal power output determined by the BKM method was 10% of 1RM and by the COGM method 30% of 1RM (Figure 1). A paired comparison of an average output measured by the BKM and the COGM method indicates practically significant differences, which differ from 420 W for a load of 0% of 1RM (ES = 2.3) to the difference 171 W for a load of 90% of 1RM (ES = 1.9). Moreover the utmost power output measured by the COGM method practically differs from the COGM power output measured with a load of 10 and 50% of 1RM by 116 W (ES = 4.3) and by 297 W (ES = 11.4) respectively.

Fig.1 The relationships between the mean power output (W) (±SD) and a load (% of 1RM). Solid line represents the BKM method and dashed line the COGM method (*n* = 2 trials).

DISCUSSION

Power output could be defined as a product of the velocity of the centre of moving body segments and the exerted force induced by muscle activity [4]. Regarding the BKM method it is mistakenly believed that the speed of barbell movement is identical with the speed of COG movement as is shown in fig. 2.Consequently, even force is overestimated by the BKM method, especially the one with lower loads 0, 10, 30 a 50% of 1RM.The overestimation of speed and force in lower loads can also be the reason of an optimal load determination on 0% of 1 RM for the CMJ exercise in some previous studies [1].

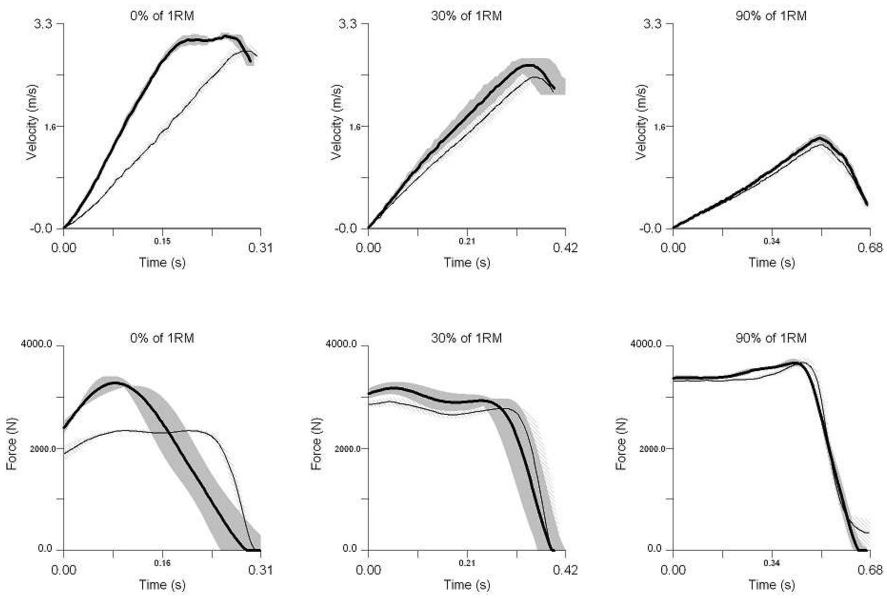


Fig.2 The velocity time and force time relationship for a load of 0, 30 a 90% of 1RM. Bold solid lines represent mean, gray areas standard deviations (±SD) of the BKM method and thin lines represent the mean (±SD) for the COGM method (*n* = 2 trials).

CONCLUSION

The optimal load for the thrower´s dynamic effort strength training of the CMJ exercise was 30% of 1RM thus 54 kg (of all the loads studied). The Barbell kinematic method underestimated the optimal load by maximum 20% of 1RM against the COG kinematic-kinetic method.

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ACKNOWLEDGEMENTS: This research was supported by the Grant Agency of the Czech Republic (No. 406/08/0572).

OPTIMIZING ROWING SPECIFIC POWER IN 4 ELITE FEMALE ROWERS BY HEAVY STRENGTH TRAINING

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BACKGROUND

Four Danish elite female rowers, who won bronze at the World Championships in 2008 and were training for the Olympics in London 2012, were followed during 1½ year of strength training (ST) to evaluate the effect on rowing performance. In championship rowing, competitors take a 6-7 min to complete the 2000 m course. At least 70 % of the energy comes from aerobic processes and maximum 30 % by anaerobic processes [1]. The legs produce the primary part of the work and peak force reaches 500-1000 N in females [2]. Top rowers are therefore characterized by having a high VO2max, a high anaerobic power and capacity and certain level of maximal muscle strength [1]. Obviously training has to tax these physiological areas, and the ST programs were designed to increase muscle strength and muscle mass. Increased muscle strength is believed to increase rowing specific power in the oar cycle, or lower the relative work load. Increased muscle mass is thought to increase the ability to produce more total work by anaerobic processes, because of larger glycogen deposit, larger cross sectional area, more enzymes and metabolites involved in energy production in addition to removal of lactic acid. Thus, the aim of the present intervention was to optimize rowing specific power by adding heavy ST to the rowers´ training. To evaluate a possible performance enhancing effects of strength training, a specific rowing test (Drag test) was designed and performed in addition to standard physiological tests performed by the rowers.

METHODS

Subjects: Four female open weight (≥59 kg) rowers at the age 26.5 (±3) years, 180 (±2.2) cm tall and weighing 71.8 (±6.3) kg (pre intervention weight) participated.

Strength training programs: Doing ST was not totally new for the rowers. However, this ST intervention, starting February 2009, was set apart by high quality in terms of quantity and weekly supervision of the ST. Type and quantity of exercises, training loads and the frequency of training sessions per week were periodized in a traditional linear manner. All sessions were whole body and comprised 4 to 7 exercises. The primary exercises were power clean, dead lift, squat, leg press, bent over row, prone bench pull, lying and inverted row, good mornings, upright rows, bench press, dumbbell press and different abdominal and lower back exercises. The load used was in the interval between 12 and 4 repetition maximum (RM) (e.g. ~70-90 % of 1 RM) and 2-4 sets of each exercise were performed. ST had high priority, from October to April, hence 3 sessions a week were performed (in addition to 5-9 rowing training sessions/week and 0-2 core stability training sessions/week), and until February 2 sessions were performed separately and prior to rowing training. From March only 1 session was performed separately from rowing training. In April throughout August 2 ST sessions were performed in combination with rowing training (in addition to 8-12 rowing training sessions/week). In addition, and throughout the intervention 1-5 of the week's rowing training sessions was reserved to anaerobic production training; 40-60 s x 8-10 repetitions and a rest in between of 5-10 min, performed on water or on the ergometer.

Drag test: The drag test is a rowing specific power test which is carried out as 5 times 100 meter all-out rowing at max tempo and with fixed start in a solid ergometer (Concept 2, Morrisville, Vermont USA) and with 4 minutes of rest in between trials. The drag factor on each of the 100 m was set at 80 (lightest resistance), 105, 130, 155 and 170 (heaviest resistance), respectively. Drag 80 represents power produced at fast oar cycle frequency (e.g. top speed power) and drag 170 represents power produced at slow oar cycle frequency (e.g. starting and acceleration power). The average power over each 100 m distance and number of oar cycles was recorded automatically by the ergometer´s software.

Fat free mass (FFM), power and VO2max: On three separate occasions rowers were taken to the lab for standard physiological testing (March ´09, March ´10 and July ´10). FFM was estimated

by the 4 point skinfold technique (Harpender caliper). VO2max was measured (Ergo-Oxyscreen-Sprint, Jäeger, Germany) on the ergometer (Concept 2, Morrisville, Vermont USA) during a 6 min distance trial and power is given from the ergometer´s software (Table 1).
Statistics: No statistics were performed on the collected data because of the small sample size, thus data must be interpret with caution.

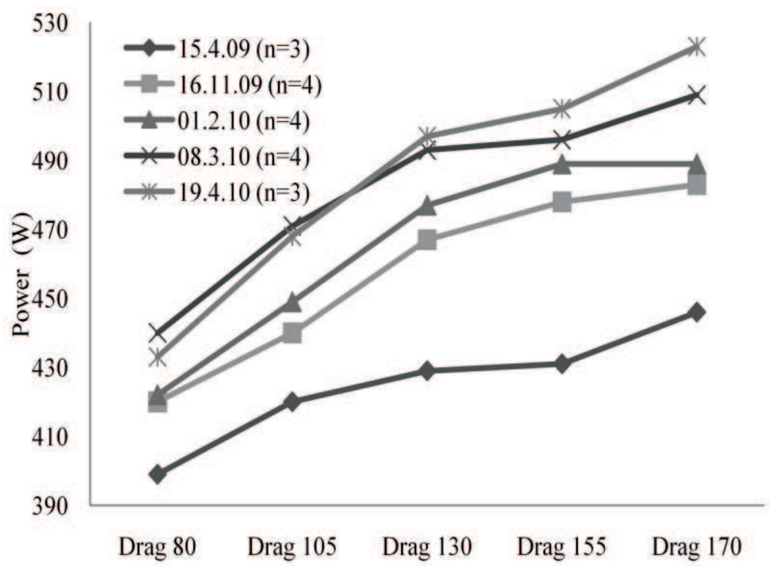

Figure 1. Drag test; 5 times 100 meter all-out rowing performed in an ergometer with different drag factors (80 – 170) and with 4 minutes of rest in between trials.

RESULTS

An increase of 10-15 % in power produced on each drag in the drag test is seen between the start of the intervention in April 2009 to the test in April 2010 (Figure 1). All rowers increase their FFM over this period (average increase = 2 kg). However, a small decrease was seen from March to July 2010. VO2max demonstrated the same picture. Power measured during the 6 min distance trial does also increase during the intervention period but instead of decreasing as FFM and VO2max towards July 2010 it stagnates (Table 1).

Table 1. Fat free mass (FFM), power and VO2max, measured during the standard physiological tests.

	24.3.09 (n=4)	15.3.10 (n=4)	14.7.10 (n=4)
FFM (kg)	52.8	54.6	53.9
Power (W)	290	307	308
VO2max (l/min)	4.0	4.3	4.2

DISCUSSION

The picture from the drag tests shows that the rowers increased their performance throughout the intervention period. We believe that these continuous improvements are a result of the ST performed, since the drag test was designed to evaluate rowing specific power, and should therefore be sensitive to training taxing the rowing specific power and thus ST. On the other hand the intensified anaerobic production training on water probably also influence on the drag test. Hence, the improvements seen in the drag test could be a mixture of the ST performed and the intensified anaerobic production training on water. In support of the above is the continuous increase in power, measured during the standard physiological tests, from March 09 to July 10, but also the gain in FFM. Interestingly, of power, FFM and VO2max, only power continued to increase (or stagnates) whereas FFM and VO2max decreased from March 10 to July 10. The decreases in FFM and VO2max are expected seasonal changes, however decreases in FFM should be minimized. Finally, the study also revealed that a fairly large ST volume (1-3 times a week) could be added to the rowers training without impeding the development in VO2max.

CONCLUSIONS

The addition of ST increased the rowing specific power in the drag test. We cannot with certainty say that the increases were a direct effect of the ST performed or a mixture of the intensified anaerobic production training on water and strength training or only due to the rowing training.

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DIFFERENCES IN MAXIMAL VOLUNTARY CONTRACTION VALUES ARE NOT MIRRORED IN THE ABILITY FOR SUBMAXIMAL FORCE GRADATION

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INTRODUCTION

A specificity of strength training effects regarding training mode, type of contraction, and angle and velocity have been documented in literature [1,2]. Previous studies on bodybuilders have shown training-specific characteristics regarding the relationship between muscle cross sectional area and mechanical output of the neuromuscular system [3]. Experimental evidence indicate that long-term effects of strength training are very diverse and include increase in supraspinal neuromuscular drive, spinal reflex responsiveness [4], and muscle mass [5,6]; and further changes in muscle-tendon architecture [7], sensory-motor integration [8], and muscle contractile properties [9]. To the contrary of everyday beliefs, studies have shown there is no cost of fine force gradation and movement precision as a result of intensive strength training [10]. The aim of this study was to test potential differences between a group of subjects with long history of strength training and a match group of normal healthy subjects in knee extensors` (i) maximal voluntary isometric force and (ii) ability to execute dynamic finely graded contraction at submaximal level. Additionally, we observed the inter-relation between the two tested motor tasks across both groups.

METHODS

Twenty-two health male subjects volunteered for the study. Half of them had a long history of regular high intensity strength training (experimental group (height 184.9 ± 4.3 cm; weight 102.6 ± 7.3 kg)) and the other half were normal subjects with no special training history (control group (height 180.9 ± 5.3 cm; weight 77.8 ± 6.0 kg)). Each subject underwent a set of tests starting with anthropometric measurements of body height and weight, subcutaneous fat tissue and muscle mass measurements. This was followed by a standardized 20-minute warm-up. After that, a person was seated on an isometric knee extension measurement chair with hips fixed at 90° and distal part of the left shank attached to the measurement lever arm at the knee position of 60°. In this position a set of three maximal voluntary contractions (MVC, peak 1-second force observed) and three 60-second repetitions of dynamic active torque tracking task (ATT, range 0-60% MVC normalized error observed) were carried out. Adequate rest intervals were introduced between repetitions in order to avoid development of fatigue. Average of the tree repetitions were calculated and used for further statistical analysis (mean ± s.d.). For all the observed parameters, descriptive statistics were calculated. The between groups differences were tested using independent samples t-test ($p < 0.05$, all df = 20). Intra-class (ICC) and Pearson's correlation coefficient (r) were used to test repeatability and to observe inter-relation between the two tests, respectively.

RESULTS

Tests of the between groups differences for anthropometric factors showed statistically significant differences in body weight (103.6 ± 7.3 vs. 77.8 ± 6.0, $t = 8.69$, $p = 0.000$), fat tissue percentage (12.2 ± 3.5 vs. 9.9 ± 0.9, $t = 2.12$, $p < 0.05$) and muscle mass (46.1 ± 3.1 vs. 35.2 ± 2.8, $t = 8.65$, $p < 0.001$), while body height was not statistically significantly different ($p \geq 0.05$). Experimental group showed statistically significantly higher MVC values compared to the control group (443 ± 55 vs. 331 ± 83, $t = 3.08$, $p < 0.01$), while no statistically significant differences were observed for ATT (1.75 ± 0.50 vs. 1.53 ± 0.23, $p \geq 0.05$) (Fig. 1).

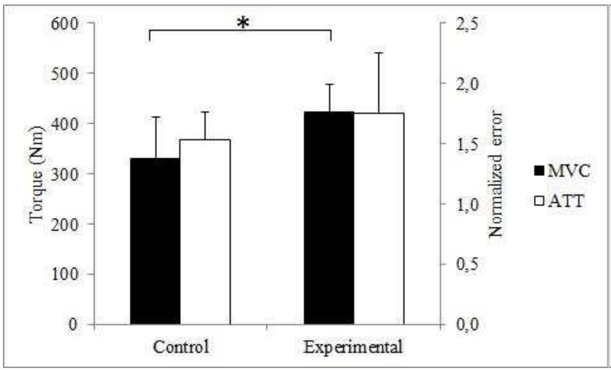

Fig. 1 Mean values and standard deviations of MVC and ATT, (* p < 0.01).

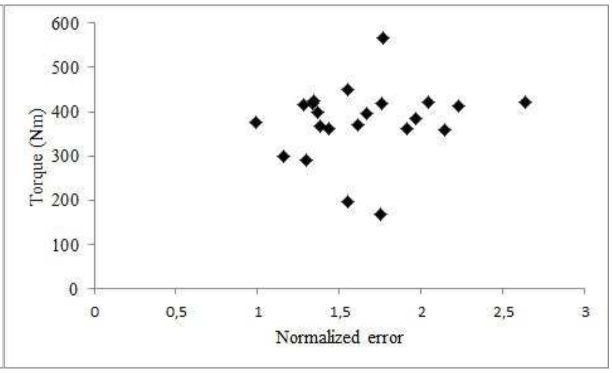

Fig. 2 Scatter plot of MVC : ATT (r = 0.169).

The Pearson's correlation coefficient between MVC and ATT was 0.169 ($p \geq 0.05$) (Fig. 2). The ICC of MVC for single measures was 0.976 and for average measures was 0.992, while the ICC of ATT for single measures was 0.737 and for average measures was 0.894.

DISCUSION

Neuromuscular strength, as one of the basic functional abilities of a human body, has an important athletic as well as everyday life value. Regarding the latter, precise regulation of submaximal muscle force is sometimes even more important than maximal mechanical output. We believe there is a gap in research literature regarding studies addressing submaximal strength tasks. Results of this study suggest that very strong athletes obviously dominate in maximal force production, however, no significant differences were observed in dynamic active tracking of low forces. Both biomechanical measurements used in this study turned out to be highly repeatable, which was already known for the maximal output parameters. However, the newly introduced knee active tracking task, adopted from hand grip and position tracking tasks originating from motor control studies, also showed very promising ICC average measures values. Finally, low level of correlation between ATT and MVC additionally suggests relative independence of both motor tests, which probably means that also the underlying mechanisms of neuromuscular regulation might differ significantly.

CONCLUSION

In summary, findings of this study showed that subjects with a background of intensive strength training express significantly higher levels of maximal knee extension isometric forces, but, they are not either significantly less or more precise in fine regulation of submaximal forces as compared to recreational healthy controls. Indices for relative independency of submaximal and maximal force tasks seem to be additionally supported by low correlation between the two.

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THE RELIABILITY OF SHOULDER STRENGTH TESTING IN REGARD TO GENDER*

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INTRODUCTION

The reliability in isokinetic strength measurement is still discussed because of ambiguous attitudes to reliability. In the classical test theory, the observed score is composed of the true score and errors. Sources of error include biological variability, instrumentation, error by subject, error by the tester [6].The most used reliability coefficients are the Pearson product moment correlation coefficient and the intraclass correlation coefficient (ICC). The use of the Pearson coefficient is critized because it cannot detect systematic error. The ICC has useful application to the sensitivity of the group heterogenity and to the variability of errors. The intraclass correlation coefficient is used for the test-retest model but also for more repetitions than two [6]. Isokinetic strength is characterized by exercise with an acommodating resistance and fixed speed. Isokinetic dynamometry has been used in clinical and sport practice [2]. Only a few studies have dealt with the reliability of upper body isokinetic strength [3,4,5]. The aim of the study was to assess gender differences in the reliability of shoulder isokinetic strength.

METHODS

Eight women (mean age 24.8, *s* = 3.5 yr; body mass 58.8, *s* = 4.4 kg, height 164.9, *s* = 5.2 cm) and 8 men (25.4, *s* = 4.9 yr; body mass 75.3, *s* = 3.6 kg, height 180.4, *s* = 4.9 cm) volunteered for the study. Testing was performed on a Cybex Humac Norm isokinetic dynamometer. The concentric isokinetic strength was tested during the shoulder extension and flexion at angular velocities 90°/s (2 rep.) and 120°/s (8 rep.). The reliability was calculated using the ICC (3,k) for all participants and then separately for males and females. The ICC (3,k) corresponds to the 2-way mixed model computed as $\mathbf{(MS_s - MS_e)/\ MS_s}$, where $\mathbf{MS_s}$ corresponds to subjects mean square and $\mathbf{MS_e}$ to error mean square [6].

RESULTS

Table 1 shows the ICC values of peak torque, total work and average power of shoulder flexors and extensors. There were no systematic differences between males and females. The ICC evaluated seperately for men and women ranged from 0.63 to 0.99. The ICC for both sexes exceeded 0.95.

		Angular velocity 60°/s				Angular velocity 120°/s			
ICC	**Gender**	**Flexion**	**Extension**	**Flexion**	**Extension**	**Flexion**	**Extension**	**Flexion**	**Extension**
PT-R	***M***	**0.95**	**0.94**	0.97	0.99	**0.93**	**0.93**	0.98	0.99
	F	0.67	0.91			0.86	0.93		
PT-L	***M***	**0.94**	**0.76**	0.97	0.97	**0.95**	**0.65**	0.98	0.97
	F	0.95	0.99			0.92	0.93		
TW-R	***M***	**0.93**	**0.79**	0.95	0.98	**0.98**	**0.97**	0.99	0.99
	F	0.81	0.98			0.95	0.96		

* The study was supported by the grand of Ministry of Education MSM 0021620864 and the grand of Czech Scientific Foundation GAČR 406/08/1514.

TW-L	***M***	**0.91**	**0.91**	0.96	0.98	**0.94**	**0.91**	0.98	0.98
	F	0.93	0.95			0.94	0.91		
AP-R	***M***	**0.97**	**0.93**	0.98	0.99	**0.95**	**0.85**	0.98	0.99
	F	0.89	0.94			0.93	0.93		
AP-L	***M***	**0.94**	**0.89**	0.98	0.99	**0.91**	**0.63**	0.98	0.98
	F	0.93	0.92			0.90	0.92		

Tab.1 The intraclass correlation coefficient (ICC) of the peak torque (PT), total work (TW) and average power (AP) for the right (R) and left (L) limb in males (M) and females (F)

Repeated measure ANOVA did not confirm significant differences between measurements. The main part of variance of nonreliability was therefore accounted to residuals.

DISCUSSION

Some authors [3,5] suggested that ICC values over 0.90 indicated excellent reproducibility. Our results exceeded the value of 0.95 for all tests when assessing reliability for both genders together. But the ICC ranged between 0.63 to 0.99 when calculating both genders separately. The ICC depends on heterogenity of the group, age, athletic background, number of test repetition, rest intervals during testing and test protocol [1,2]. The heterogenity of the group increases the ICC [6]. In the current study, higher differences in the strength between men and women produced a higher values of ICC. We recommend, therefore, that the question of gender is taken in consideration when assessing the reliability of isokinetic strength testing.

CONCLUSION

The current study confirmed high reliability for the specific shoulder isokinetic strength test. We did not found differences in reliability between males and females but the reliability coefficient is lower when assessing strength only for one gender.

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PREDICTION OF OPTIMAL ISOMETRIC HAMSTRING TO QUADRICEPS RATIO

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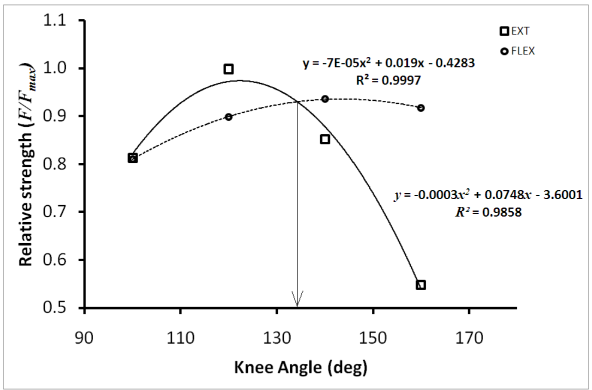
INTRODUCTION

The hamstrings to quadriceps (*HQ*) ratio has received a lot of attention regarding its use in rehabilitation and physical conditioning [2]. Although mostly assessed from the measures obtained from isokinetic tests, due to its obvious simplicity cost-effectiveness and high test-retest reliability, tests based on isometric dynamometry are also widely used. The typical *HQ* ratio of a healthy knee ranges from 0.5 to 0.8, depending on knee angle and angular velocity [1,2]. The great variability of obtained values makes it difficult to use in practice. Moreover, quadriceps and hamstrings could exert maximal strength at different knee angles, which rise the question on which angle should their strengths be assessed, in order to calculate the most appropriate *HQ* ratio. To address some of the aforementioned questions, we designed a study in which we have measured maximal isometric hamstrings and quadriceps strength at various knee angles, and calculated corresponding HQ ratios. The goal of our study was to determine optimal angle on which isometric tests for both muscle groups should be applied, in order to obtain most appropriate HQ ratio. To test the usefulness of the determined values (obtained from healthy athletes), we have compared them with the HQ ratios obtained from athletes with recent knee injuries.

METHODS

Twenty male university students aged between 22 and 26 years, participated in the study. All of them were physically active and none of them reported either neurological disorders or recent injuries. Maximum isometric strength (F_{max}) of quadriceps and hamstrings of the dominant leg, at four randomly selected knee angles (100^0, 120^0, 140^0 and 160^0, were 180^0 represents full extension), was assessed using a Kin-Com isokinetic dynamometer (Chatex Corp., Chattanooga, TN). Isometric *H:Q* ratios at four knee angles, were calculated as follows: *HQ* = Hamstrings F_{max}/Quadriceps F_{max}. Average (across the subjects) maximal isometric strength for each knee angle was normalized with respect to maximal obtained value for the corresponding muscle. Relative strength –knee angle was interpolated with the polynomial function of the second order. Optimal angle was obtained solving the system of these two functions. The optimal HQ ratio was then obtained from the *HQ*-knee angle relationship. Additional 6 athletes with the recent ACL reconstruction (4-6 months after operation) were tested at the determined optimal knee angle, and *HQ* ratios for healthy and injured leg were calculated. These values were compared with "optimal" *HQ* ratio, using t-test for independent samples.

RESULTS



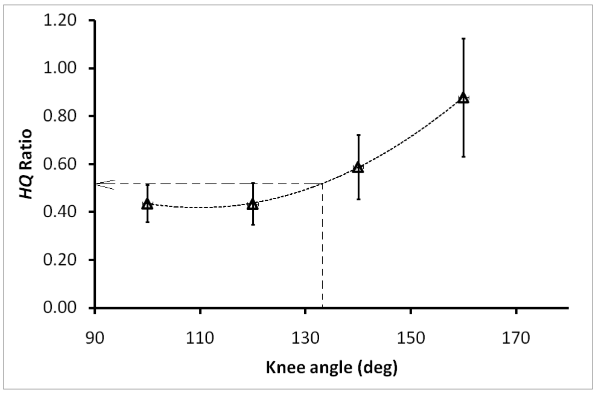


Fig.1 Normalized quadriceps (squares) and hamstrings (circles) strength – knee angle (left) and HQ-knee angle relationship (right).

The maximum of quadriceps and hamstrings relative strength –knee angle functions occurred at 120 degrees and 150 degrees, respectively. The solution of the system of these two functions for knee angle revealed "optimal" knee angle at 135 degrees. Corresponding optimal *HQ* ratio (on the *HQ* ratio-knee angle) were found to be 0.55. The mean (SD) *HQ* ratios of healthy and injured leg (injured athletes) obtained at the knee angle at 135 degrees, were, 0.52 (0.08) and 0.73 (0.09). When the *HQ* ratios of healthy and injured leg were compared with previously determined optimal value, differences were found only for injured leg ($p<0.05$).

DISCUSSION

The attempt in this study was to determine so cold optimal knee angle for isometric maximal strength tests applied on antagonistic muscle groups. The values of *HQ* ratios reported in previous studies [1,2] were ranged in the wide interval (0.5-0.8). The difference between reported results could be explained by the fact that strength tests were performed at various knee angles. *HQ* ratios obtained in our study are in line with these results. The suggested optimal angle is between the angle on which quadriceps (120 deg) and hamstrings (150 deg) exert maximal strength. Differences between optimal *HQ* ratio and the one obtained from injured leg are expected in this phase of rehabilitation process, and are in line with results of other authors [1,3].

CONCLUSION

Although this study was performed at the limited number of subjects, having in mind that the *HQ* ratio is affected by the number of factors, the obtained findings could suggests that the quadriceps and hamstrings strength tests, performed at the optimal knee angle, and corresponding *HQ* values obtained at the optimal angle, could be used in follow up of rehabilitation after knee injuries.

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STRENGTH AND FUNCTION OF THE SHOULDER TWO MONTHS AFTER THE ROTATOR CUFF RECONSTRUCTION

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Introduction

Rotator cuff tear is one of the most common distresses of the shoulder constituting about 25 % of all the shoulder operations in Finland (Rosenberg et al. 2006). There is a lack of information concerning strength and function of the operated shoulder after a rotator cuff reconstruction. Thus, the purpose of this study was to find out, how the rotator cuff reconstruction effects on strength and functional ability of the shoulder two months after the operation.

Subjects and methods

Subjects. A total of 67 consecutive patients (38 men and 29 women), who had gone through a rotator cuff reconstruction due to a rotator cuff tear, were recruited to the study. The inclusion criteria were age of 18–65 years and a rotator cuff tear less than 5 cm. The exclusion criteria were previous surgeries in the affected shoulder, cervical intervertebral disc prolapse, status post cervical spine surgery, spinal canal stenosis, signs of remarkable joint arthritis, rheumatoid arthritis, fibromyalgia, pregnancy, serious mental illness or social problem and severe cardiac disease or neurological disorder.

Methods. Isometric shoulder strength measurements were carried out using a dynamometer (Ds Europe, Mod. 546QTD strain gauge, Milano, Italy) and analyzed with Protacon software (Jyväskylä, Finland). During the measurement of internal and external rotation of the shoulder the patient was sitting in an upright position, with a sturdy barbell between the body and upper arm to prevent the use of the body during the measurement. The upper arm was kept in 20° flexion. The measurement sensor was placed above the wrist at the level of the processus styloideus. During the isometric shoulder flexion strength measurement the patient was sitting with upper arm in 90° flexion, 30° horizontal abduction, and keeping the elbow straight. The measurement sensor was placed at the level of the processus styloideus. Two warm-up contractions were performed prior to the maximal tests. Three maximum performances were made to each measurement direction and a one-minute rest period was taken between each trial. If the third performance improved more than 5 % from the best result, additional trials were performed. The best result of each measurement was used in the final analysis. The grip strength was measured with a Saehan dynamometer (Model SH5001, Masan, Korea). Visual analogue scale (VAS scale from 0 to 100 mm) was used to assess shoulder pain during strength measurements (Dixon & Bird 1981). Patients filled in a ten item questionnaire modified from ASES, assessing functional capacity related to putting on a coat, sleeping on painful or affected side, washing back, managing toileting, combing hair, reaching a high shelf, lifting 4 kg above shoulder, throwing a ball overhand, doing usual work, doing usual sport, scale from 0 to 30; the higher the value, the better functional ability (Richards et all. 1994).

Data analysis. The results are expressed as means and standard deviations (SD). Statistical comparison between the sides was carried out using the paired t-test and correlations were analyzed using the Pearson correlation. The α level was set at 0.05 for all tests.

Self-administered rehabilitation. After the operation the arm was supported in a suspension bandage for three weeks and was allowed to be flexed or abducted only with the help of the other hand. However, the patients were allowed to do light home work without the bandage keeping the arm near the body. Postoperative home exercises, such as passive assisted shoulder exercises, Penndel, active elbow and finger exercises were given to patients. Two weeks after the operation the exercises included also, light isometric contractions of shoulder in flexion, extension, and internal and external rotation. Six weeks after the operation the patients were allowed to start dynamic mobility and strengthening exercises.

Results

The mean (SD) age of the patients was 54 (6) years (range 41-62) and BMI 28 (4) (range 21-41). The mean duration of the shoulder symptoms before the operation was 41 (69) (range 1-180) months. Most of the patients (70 %) had the shoulder operation done on the dominant side.

Two months after the operation the internal rotation strength was 13 %, the external rotation strength 35 % and the flexion strength 49 % lower on the operated side than on the contra lateral side (Table 1). Pain was significantly higher on the operated than on the contra lateral shoulder during all the strength measurements. Also, the shoulder function index was statistical significantly lower on the operated side. The most affected functions of the operated shoulder were throwing a ball overhand, lifting 4 kg above shoulder and washing back.

Table 1. Mean (SD) shoulder muscle strength, pain during loading and functional ability index of the operated and contra lateral shoulder two months after the rotator cuff operation.

		Operated shoulder	Non-operated shoulder	P value
Strength, kg	Internal rotators	12,9 (5)	14,8 (5)	<0.001
	External rotators	6,9 (3)	10,6 (3)	<0.001
	Flexion	4,7 (2)	9,2 (3)	<0.001
	Grip	39,2 (13)	42,3 (13)	<0.001
Shoulder pain during the strain, mm, (VAS scale 0-100)	Internal rotators	7 (12)	2 (7)	0.001
	External rotators	10 (15)	1 (5)	<0.001
	Flexion	20,5 (24)	2,6 (7)	<0.001
	Grip	3,2 (9)	0,2 (2)	0.010
Shoulder function index (scale 0-30)		18 (6)	29 (3)	<0.001

Discussion

The results showed that the operated shoulder was significantly weaker, more painful and its functional ability was poorer compared to the non-operated shoulder. The finding is in line with a recent study by Borgmästars et al. (2010) reporting that two months after the rotator cuff operation the internal rotation strength was 1 %, external rotation strength 15 % and flexion strength 28 % lower on the operated side than on the contra lateral side. In the present study the strength differences between the operated and the contra lateral shoulder were even greater; 13 %, 35 % and 49 %, respectively. The patients usually return to work and other normal physically loading activities two months after the rotator cuff operation. However, if the work tasks are heavy and demanding the strength and function of the operated shoulder might not be sufficient for such loading increasing the risk of reinjures.

Conclusion

The deficit of strength and function of the operated shoulder two months after the operation showed that systematic progressive shoulder rehabilitation is preferred to start at to ensure that the shoulder function recovers so that patients can safely return to their work and previous activities.

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FULL SQUAT LOAD-POWER PROFILE: GENDER DIFFERENCES

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INTRODUCTION

A complete description of the load-power profile of the most commonly used resistance training exercises may be useful for strength and conditioning coaches in order to optimize training program design for both male and female athletes of different sports and/or with different strength and power levels. Since there exists a paucity of data in the literature analyzing the full squat, we aimed to describe the load-power relationship for this exercise.

METHODS

One hundred and three well-trained subjects: 76 male (age 19.2±2.7 yr, body mass (BM) 70.7±1.7 kg, body mass index 24.3±4.6 kg·m^{-2}; fat-free mass 61.9 kg; body fat 12.5%) and 27 female (age 17.1±1.8 yr, BM 57.0±7.1 kg, body mass index 24.3±4.6 kg·m^{-2}; fat free mass 47.9 kg; body fat 15.9 %) volunteered to take part in this study. All subjects had at least three years of strength training background. Each subject performed a full squat strength test for the determination of the one-repetition maximum (1RM) and the complete load-power relationship in a Smith machine. A dynamic measurement system (T-Force System, Ergotech, Murcia, Spain, 0.25% accuracy) automatically calculated the relevant kinematic and kinetic parameters of every repetition, provided real time information on screen and stored data on a disk for subsequent analysis. Each subject was carefully instructed to perform each concentric phase in an explosive manner. Strong verbal encouragement and velocity feedback in every repetition was provided in order to motivate the participants to give a maximal effort. The initial load was set at 50% of each subject's body mass, and was progressively increased to 75%, 100% and 125% when it was feasible. When mean propulsive velocity was lower than 0.5 m · s^{-1}, the load was adjusted with smaller increments (5-2.5 kg). The heaviest load that each subject could properly lift to the full extension of his knees was considered to be his 1RM. For comparison purposes, the relative strength ratio (1RM/BM), maximum muscle power output attained during the incremental test as well as the percentage of 1RM (W_{peak}/%1RM) and the percentage of BM (W_{peak}/%BM) that maximizes power output were calculated.

RESULTS

No significant differences were detected between genders for W_{peak}/%1RM. The male group demonstrated higher 1RM/BM and W_{peak}/%BM values compared to the female group (Fig. 1).

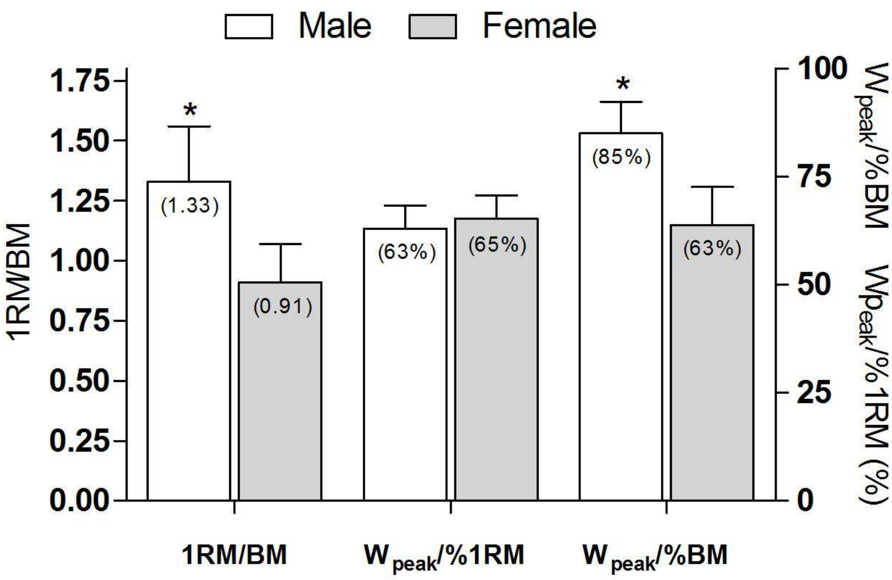

Fig.1 Differences between genders in 1RMrepetition maximum relative to body mass, load (%1RM and %BM) that maximizes power output in the full squat exercise. * $p<0.05$

DISCUSSION

One of the major findings of the present study was that maximal strength (1RM) and power output in the male group were superior, not only in absolute terms, but also when normalized to kilograms of body mass compared to female subjects. These neuromuscular differences could be mainly attributed to: a) male subjects having higher fat-free mass and therefore total muscle mass that can generate force compared to female subjects; b) the neural activation patterns and/or twitch tension per muscle mass under maximal and submaximal concentric actions are also diminished in female compared to male subjects [3]. On the other hand, the absence of differences between male and female groups for the percentage of 1RM that maximizes muscle power output suggest that independent of the subject's gender and maximal strength, the load that optimized muscle power output is very close to 60%-65% 1RM in the full squat exercise. These results are similar to those previously described [1,2,4] where no significant differences were detected in the percentage of 1RM that maximizes muscle power output in the half-squat and bench press exercises between male subjects with different relative strength.

CONCLUSION

Although females possess lower absolute strength, the relative load (%1RM) that maximizes the mechanical power output in the full squat exercise is very similar between males and females.

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ANALYSIS OF HORIZONTAL AND VERTICAL FORCES IN DIFFERENT STARTS POSITIONS IN COMPETITIVE SWIMMING.

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INTRODUCTION

The start takes almost 10% of the swimming performance in 50 m and 5% of the swimming performance in 100 m [6]. The basic start was first time presented by Erik Hanauer in the 60's in the 20th century. It has been used until now [2], although the track start is preferred today. The swimming start represents quite simple kinematical structure of human movement in space. The greatest attention in professional literature is paid to the length of its duration. We evaluate time which is needed to get off the blocks after the start signal, flying time until the water is touched and time of floating [3,4,5]. The most important relation with the start was found between the start and the floating duration (r=0,97) [3]. As a part of the start there are except for space-orientation characteristics also force-time characteristics. Those are analyzed in the paper in four different types.

METHODS

We observed 9 performance swimmers at the age of 20-26 years, who had performed swimming for 8-14 years. We realized testing in the main part of the summer season. We monitored speed-force parameters on start dynamometric platform fastened on start blocks. Dynamometric platform was equipped by 5 tensometers, where 4 tensometers were placed in the corners of the platform. The tensometers measured vertical-horizontal force after leaving the blocks. With the program Fitronic-Forcel2 we registered: start reaction (SR), horizontal force (HF), vertical force (VF), force vector (VcF). The parameters were evaluated in four different types of start (grab start, track start, track start with strain, grab start with strain).

RESULTS

We found higher values in maximal vertical force in comparison to horizontal force. The highest force was achieved in track start with strain (1601N, Fig.1, Tab.1). The maximal horizontal force was measured in grab start (939N, Fig.2., Tab. 1). The shortest start time was monitored in track start 898 ms, where the maximal vertical and horizontal force was the lowest (Tab.1.). Use of maximal vertical and horizontal force calculated by vector of these forces was monitored in track start with strain (1694 N, Tab.1., Fig. 3).

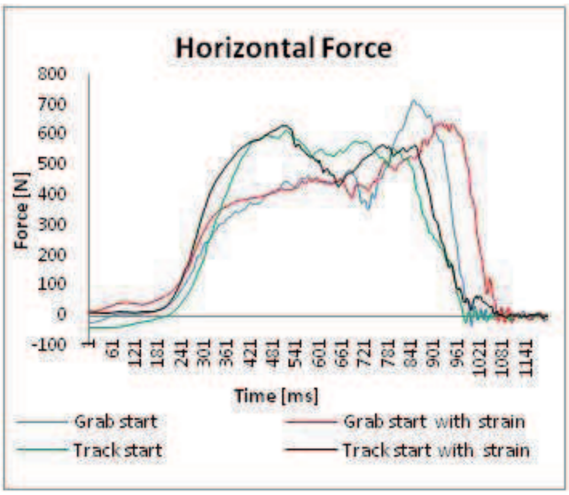

Figure 1 Vertical force in four types of start

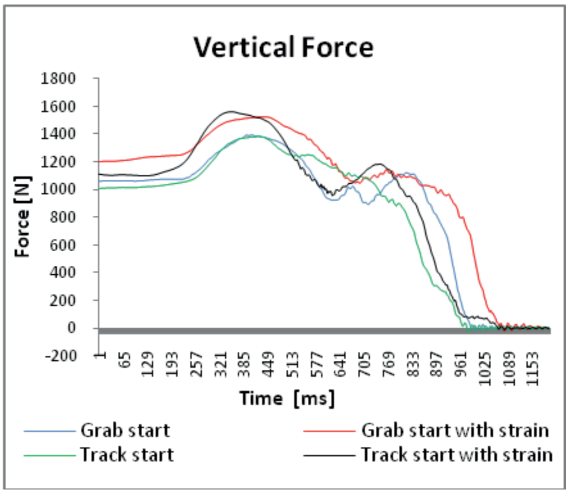

Figure 2 Horizontal force in four types of start

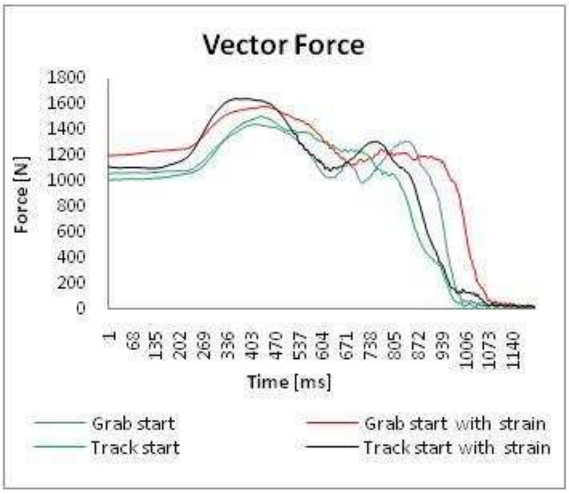

Figure 3 Force vector in four types of start

Table 1 Speed-force parameters in four types of start

	Grab start	Grab start with strain	Track start	Track start with strain
SR (ms)	929	1010	898	941
VF max [N]	1495	1575	1491	1601
HF max [N]	939	919	743	748
VcF max [N]	1619	1667	1626	1694
VF aver [N]	1129	1243	1082	1153
HF aver [N]	343	353	346	342
VcF aver [N]	1212	1320	1168	1241

Curves of horizontal and vertical force had two peaks. In vertical force during all types of starts the highest level of force was achieved in time horizon 300-460 ms (Fig. 1). We found greater differences related to demonstration of speed-strength skills parameters in starts with different position of legs on the blocks. We found in time horizon 477 ms higher horizontal force in track start and in track start with strain (Fig. 2). With a delay of 400 ms higher horizontal force in grab start and in grab start with strain was monitored.

DISCUSSION

To sum up, the maximal vertical and horizontal force, which are used by the swimmer during the start, the vertical force is always higher in comparison to horizontal force. Depending on the type of start the beginning of push-off during the start always goes into vertical direction. The character of vertical force curve is similar in all monitored types of start. The character of horizontal force curve is different in basic position of legs on the start block. Swimmers, who used track start had shorter start reaction [7]. On the contrary, swimmers who used grab start had slower start reaction but entered water under optimal angle for the following speed and floating position.

CONCLUSION

A swimmer uses during a start horizontal and vertical forces and speed, which is given by the basic position of legs and arms on the block. Those forces act in horizontal and vertical direction and their curves have different time-force character. After analysis of four different types of swimmers' starts, we found highest maximal vertical force in track start with strain. Following our results we may state that the most effective starts are the starts with strains.

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Evaluation of monitoring the force parameters in breaststroke

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INTRODUCTION

Among the four swimming strokes the breaststroke is specific regarding biomechanic aspects. Harmonious movement of arms and legs, realization of pre-stroke and stroke cycles under water, that all classifies breaststroke as the technically most difficult stroke. During one stroke cycle it comes to great changes in the innercycle speed, what is followed by high demands on strength [1,2,3]. In our research we pay attention to diagnostics of force parameters in isokinetic mode in breaststroke. The possibilities of an objective evaluation of strength skills as a supposition for the sport performance are important by those speed levels, which are close to the levels of speed of concrete swimming stroke in concrete swimming discipline.

METHODS

We observed 12 men, specialists in breaststroke at the age of 20-26 years, who perform swimming 10 and more years. The swimmers were tested in water on firm cable of the swimming isokinetic dynamometer. The results were registered in computer by software Fitronic Swim. The preliminary tests were aimed at stating the optimal swimming speed for objective evaluation of force parameters of breaststroke swimmers. In the first sets of testing the swimmers had swum for 15s at various speed of 0,2 $m.s^{-1}$; 0,4 $m.s^{-1}$; 0,6 $m.s^{-1}$; 0,8 $m.s^{-1}$; 1,0 $m.s^{-1}$ and 1,2 $m.s^{-1}$. We monitored force and power parameters. We used the measured values for stating optimal speed to evaluate force parameters in breaststroke. In the next sets we used test with time 15s and speed 0,6 $m.s^{-1}$. We used basic statistical characteristics for processing the results. Spearman correlation was used to find out relations between the force parameters and sport performance in 50m, 100m and 200m breaststroke.

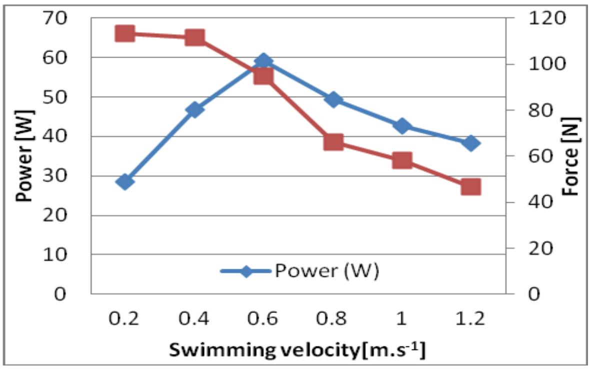

Fig.1 Average force and power at different swimming speed

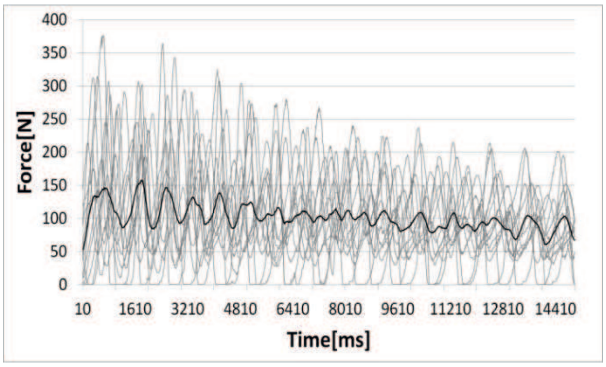

Fig.2 Average force of whole testing group during 15s at 0.6$m.s^{-1}$

RESULTS

We wanted to objectify evaluation of force parameters in isokinetic mode in breaststroke and therefore we analysed changes in average force and power of the entire monitored group at various swimming speed. The monitored group achieved the highest average force 133N and lowest average power 29W at the slowest swimming speed 0,2 $m.s^{-1}$. The values of force decreased as we increased swimming speed. We monitored average force of the group 47 N at swimming speed 1,2 $m.s^{-1}$. The maximal power was achieved at swimming speed 0,6 $m.s^{-1}$ and it decreased with higher speed levels (Fig.1). We think the duration of motor tests was optimal for the swimmers. With the first strokes the swimmer developed highest force but because of the duration of swimming discipline we consider this as irrelevant. During testing the monitored swimmers needed 2-3 strokes for synchronization of individual technique with muscular exertion, which was conditioned by swimming speed. Figure 2 presents individual force curves of 12 swimmers, where the bold line represents average force of the group in particular time section. The relation analysis confirmed statistically significant relation between average force of breaststroke swimmers monitored at swimming speed 0,6 $m.s^{-1}$ and swimming performance in 50m, 100m and 200m breaststroke (Fig.3).

	Max.	*Min.*	*Avg.*	*Med.*	*Var.*	*Sd.*	*sp50*	*sp100*	*sp200*
Max.	1								
Min.	-0,269	1							
Avg.	0,154	0,471	1						
Med.	0,042	0,484	**0,984**	1					
Var.	**0,944**	**-0,496**	0,063	-0,035	1				
Sd.	**0,944**	-0,425	0,070	-0,035	**0,979**	1			
sp50	0,294	0,322	**0,622**	**0,649**	0,273	0,252	1		
sp100	0,322	0,358	0,461	0,462	0,308	0,336	**0,916**	1	
sp200	0,338	0,307	**0,613**	**0,593**	0,310	0,352	**0,697**	**0,711**	1

Fig.3 The relation between force parameters in isokinetic mode (v=0,6 $m.s^{-1}$) and swimming performance in breastroke. Critical values: ** $p < 0{,}01$ (rk = 0,707); * $p < 0{,}05$ (rk = 0,576); (*) $p < 0{,}10$ (rk = 0,495)

DISCUSSION

We validated findings of general character in other sports [4,5], that the power does not culminate with the application of greatest force. For breaststroke we recommend to monitor strength skills in isokinetic mode in water at swimming speed 0,6 $m.s^{-1}$. The relation between force and power that is evaluated in isokinetic mode in water in different swimming strokes is not identical. For crawl the most suitable swimming speed for monitoring force is 0,8 $m.s^{-1}$ [6]. Statistically significant relations between the swimming performance in different swimming disciplines and the average force were not validated in 100m breaststroke. We consider this as a result of the swimmers' specializations in our group, where "sprinters and 200m swimmers" dominated.

CONCLUSION

The monitoring of force parameters in isokinetic mode at swimming speed 0,6 $m.s^{-1}$ is suitable for breaststroke swimmers. We proved the importance of strength skills in sport performance of breaststroke swimmers. The information about strength changes during each particular season of training should be calculated of the average values (not extreme values) with respect to inter or intraindividual approach.

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EFFECTS OF DIFFERENT WARM-UP PROTOCOLS ON NEUROMUSCULAR FUNCTIONS

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INTRODUCTION

Principle of warm-up is generally accepted in the preparations of athletes at least in all power type sports. Static stretching is commonly used as a part of warm-up routines although it may even have negative or no effects to the performance [1, 2]. Dynamic stretching, on the other hand, has been shown to enhance performance [4] but the mechanisms related to the changes in performance after warm-up are not totally clear. The purpose of the present study was to examine if active warm-up (ACT; active dynamic exercises without static stretching) would lead greater force production capability than traditional (TRAD; light running and static stretching) and whether possible differences could be explained by changes in spinal sensitivity and/or in neural activation of the lower limb muscles.

METHODS

10 male subjects (27.8±5.9 years) participated in the study. Protocol TRAD consisted of 2 minutes of light intensity running and static stretching focusing on the lower body. Subjects held each stretch for 30 seconds at a point of mild discomfort, relaxed for 10 seconds between stretches. Five muscle groups were stretched two times and total time from the beginning to the end took 10 minutes. Protocol ACT consisted of active dynamic exercises such as high knee running -, step squats -, and one leg jumps forwards and backwards. All phases were performed with high intensity with rest intervals of 10 seconds between phases. Isometric MVC and rapid force production (RFD) as a peak force of 0-200ms were measured in bilateral leg bench press with 110, 45 and 80 degrees knee, hip and ankle angles, respectively. aEMG was measured from soleus, medial gastrocnemius, vastus lateralis, rectus femoris, and biceps femoris muscles. H-reflex sensitivity (Hmax/Mmax) was measured in standing rest conditions and V-wave (V/Mmax) was measured during plantar flexion MVC from soleus muscle. Measurements were performed before and after the both traditional and active warm-ups.

RESULTS

No significant changes were observed in MVC or in aEMG during MVC after either warm-up. RFD increased after ACT (n.s) and decreased slightly after TRAD (n.s) and the relative change of RFD was significantly higher after ACT than TRAD (23.3% vs. -6.3%, $p<0.05$), respectively. (fig. 1). A significant difference between the warm-ups was also observed in the relative change of the medial gastrocnemius aEMG during the RFD (28% in ACT and -9.7% in TRAD, $p<0.05$) (fig 1). There were no significant changes in H-reflex and V-wave responses. Relative increase in V/Mmax ratio correlated significantly with relative increase of the RFD ($r=0.705$, $p<0.05$) after the ACT, which was not observed after TRAD.

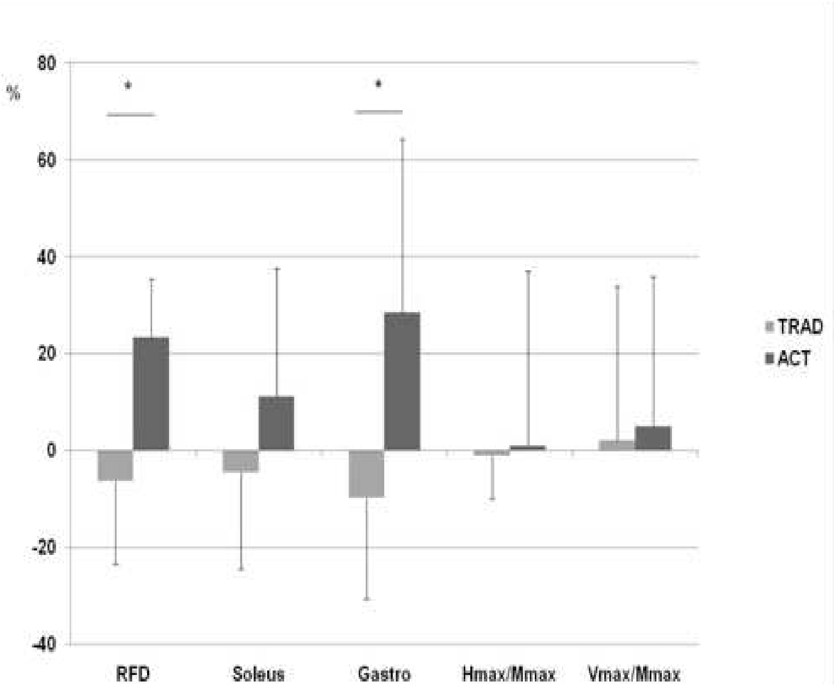

Fig. 1 Relative change of the RFD (0-200ms), aEMG of the soleus, medial gastrocnemius (0-200ms), Hmax/Mmax and V/Mmax responses after the two warm-up protocols. (* p<0.05)

DISCUSSION

These results showed different acute effects of the traditional and active warm-ups in neuromuscular performance as measured with rapid force production. Active warm-up mode seemed to activate the central nervous system more efficiently whereas static stretching led to either no changes or even small impairments. A significant correlation between V/Max and RFD found only after ACT supports these findings. Greater increase in muscle activation after ACT was found only during the early phase of the force production but not during MVC. Gruber & Gollhofer (2004) [3] found similar results after sensorimotor training and suggested that enhanced extrafacilitatory drive from the afferent system could be a potential mechanism for the improved neural activation. No changes were observed in Hmax/Mmax indicating that mechanisms related to motoneuron pool excitability were not affected by either warm-up routine.

CONCLUSION

As a conclusion, active warm-up mode seems to lead to higher activity from central pathways during the early part of the force production than traditional static stretching. This would be important especially in sport events, where fast changes of directions and accelerations and high power production is needed. Based on these results, it is recommended that active warm-up before the exercise should be used rather than traditional light intensity warm-up with static stretching.

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Friday 12:30 – 13:00

Defended Poster Session II

RELEVANCE OF ACCELERATION AND GRAVITY POWER PROFILING FOR TRAINING PRESCRIPTION

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INTRODUCTION

Determining the load-power relationship for given resistance exercises could be useful for quantifying performance changes after training and to identify the training load to maximize power output. It is has been recommended that to improve power, athletes should use this load that maximizes power output. However, it has been recently demonstrated that for some exercises, the power profile was relatively similar across a wide range of loads. As a consequence, near maximal power output could be produced at very different loads (1, 2). However, performing a squat at 20% or 80% of the 1RM, despite producing the same power output, results in very different neuromuscular activity and according to training specificity theory, working with 20% or 80% 1RM loads will result in differential training objectives as well as neuromuscular adaptations.

Recently, Quievre et al. (3) have suggested splitting total power output into two components: one linked to the force of gravity (gravity power, P_g) and one linked to the system mass resulting acceleration (acceleration power, P_a). It may be that differentiating total power output into these P_a and P_g and noting their effects, results in a different interpretation of the load-power relationship and therefore the loading and adaptational effects to muscle. We have hypothesised that profiling P_a-load and P_g-load relationships could inform programme design to better effect as to the loads to use for specific power training objectives.

METHODS

Fifteen healthy subjects (22±3yr, 1.76±0.12m, 72±13kg) participated in this study and were tested following the same modalities. A concentric bench press (BP) exercise was performed with a standardized position on a Smith machine. Subjects were tested at four increasing loads: 35, 50, 70 and 95% of the 1RM. Number of trials and recovery was adapted to the load. Subjects were instructed to lift the barbell as fast as possible.

The inertial dynamometer used in this study combined a linear position transducer and an accelerometer in order to record barbell's vertical movement. A specific Labview programme was designed in order to measure different mechanical parameters during the movement. Total power (P) acceleration power (P_a) and gravity power (P_g) were used in the present study and were calculated according to following equations:

$$P = (ma+mg)V = mav + mgv = P_a + P_g$$

$$P_a = mav$$

$$P_g = mgv$$

For descriptive data, ordinary statistical methods were employed, including means (x) and standard deviation (SD). A paired t-test was used to determine significant ($p<0.05$) differences between relative charges.

RESULTS

Figure 1 shows that the three different types of power outputs presented very different profiles. P as well as P_a significantly decreased from 35 to 95% of 1RM, but not in the same way: the reduction in power increased with load for P while it was almost constant for P_a. P_g significantly increased from 35 to 50% and decreased from 70 to 95% of 1RM. There was no significant difference between 50 and 70% of the 1RM. It can be observed from the curves (see Figure 2) that P_a has a substantial influence on P at 35% of the 1RM but not at 95% where P is almost totally influenced by P_g.

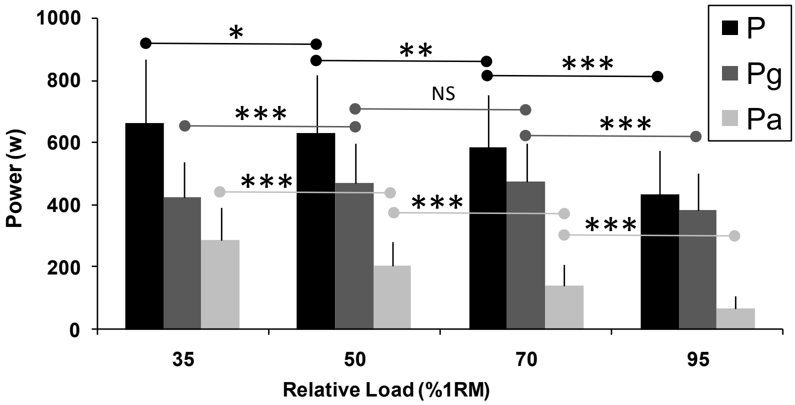

Fig.1 Means and standard deviations of each power (P, P_g, P_a) accordingly to the load. Significant differences between loads are represented by *(p<0.05), ** (p<0.01) and *** (p<0.001).

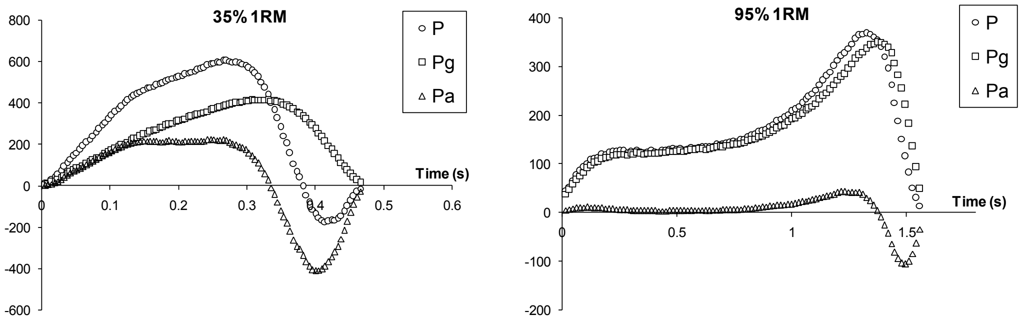

Fig.2 Curve analysis representing the evolution of the three types of power output (P, P_g, P_a) during 35 end 95% 1RM loading

DISCUSSION

The results indicate that P, P_a and P_g are not affected in the same way when load was increased, confirming the previous study of Quievre et al (3). These findings question the value of traditional power-load profiling and the use of these profiles in training load selection. Researchers have highlighted that in the squat jump and power clean, P presented little change over a wide range of loads (1,2). According to Harris et al (2), in these specific cases, profiling the P-load relationship may not be that important. With the introduction of P_a and P_g concept, it appears that using a light or heavy load should result in different training outcomes. For coaches, profiling P_a-load and P_g-load relationships could be more relevant than the classical P-load relationship in order to determine which amount of load they have to use in their power training programme. Obviously, load selection should depend on sport characteristics and the relative importance of P_a and P_g during decisive actions.

CONCLUSION

The introduction of the P_a and P_g concept should lead to new considerations regarding power output and the load to be selected to maximize muscle performance.

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A NEW AUGMENTED ECCENTRIC LOADING DEVICE: FREE BARBELL REPETITIONS WITH HEAVY ECCENTRIC AND LIGHTER CONCENTRIC LOADS

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INTRODUCTION

Many athletes use supramaximal eccentric training as part of their physical preparation. There is not 100% agreement in the scientific literature, but eccentric training has been shown to produce greater gains in muscular strength and size (1, 2). Isokinetic dynamometers are commonly used in testing and training eccentric strength, with the athlete working at a constant velocity as a servomotor controls the load. The problem is that isokinetic movements are virtually nonexistent in sport. Constant load (or isoinertial) exercise allows natural movements, but is limited by the concentric strength of the athlete. When an athlete trains with 90% 1RM, this is approximately only 60% – 75% of maximum eccentric strength.

An athlete striving to improve performance through strength gains must find ways to train maximally with eccentric loading, which is impossible with constant load training. Augmented eccentric loading (AEL) involves using an eccentric load that is heavier than the concentric load during the same exercise. Scientists and coaches have investigated ways to increase the load during the eccentric phase and decrease it for the concentric phase, so that an optimal training stimulation is produced throughout the entire exercise (3, 4).

The challenge is to design and develop a training device which would allow the free use of a barbell with heavy eccentric loads and lighter concentric loads. The most important consideration in working with supramaximal eccentric loads is safety. If safety is ensured, working with free weights is preferable as balance and coordination are needed in working with heavy loads. The aim of this abstract is to briefly describe the design and development of a training device that would provide functional eccentric overloading with free weights under standardized and safe conditions.

METHODS

A high priority was that the barbell would have 100% free range of motion during supramaximal eccentric loading. A needs analysis concluded that the following conditions must be met:

- The device will safely and quickly stop the bar if the athlete "fails" during any phase of lift.
- The bar will move freely (in all planes) during the eccentric portion of the lift.
- There will be no external adjustments to the bar load during a multiple repetition set.
- All barbell lifts in which the concentric speed does not exceed 1 m/s can be performed.
- Assistance can be provided during the concentric portion of the lift to lighten the load.
- The athlete's concentric load can be predetermined as % of the total bar load.
- The range of motion (top and bottom of lift) can be adjusted for each athlete.
- The range of motion for all lifts performed by an athlete will be saved by the device.
- The device will provide training data which can be exported for training documentation.
- The machine can be used as a spotting device during normal lifts.
- The machine would have dimensions similar to a normal power rack.
- The machine cannot be used without a coach or training partner to supervise training.

RESULTS

The Intelligent Motion Lifter (IML) is essentially 2 lifting systems, each consisting of a column with a drive spindle, a synchronized servomotor and a servo controller. A lifting fork is attached to the column via a spindle bolt and 4 recirculating ball bearing assemblies. Light grid sensors on the fork continuously measure the distance of the bar from the fork. The IML is controlled by a 1.1 GHz programmable logic controller. The coach or training partner must use the hand-held

remote control which has a "hot button". The hot button must be activated in order for the system to function, and the forks will automatically stop if the button is released.
The forks have a maximum speed of 1 m/s, maximum acceleration of 2 m/s^2 and a maximum load capacity of 450 kg. The highest upper position of the forks is 216.5 cm and lowest position is 59 cm from the floor.


Fig.1 Eccentric squat


Fig.2 Remote control


Fig.3 Eccentric bench pull

There are 4 operating modes.
In the automatic positioning mode, the forks are positioned under the bar (but without contact). The forks follow the path of the bar at a predetermined distance (12.5 – 100mm) under the bar. The athlete is able to train normally with no help from the machine.
In the automatic velocity mode, the forks move the bar at a pre-selected constant velocity between the set upper and lower limits. The automatic positioning is disabled and the barbell rests on the forks. The athlete can work during one phase (concentric or eccentric) or both. The applied force which the athlete exerts on the bar is measured and can be recorded.
The controlled load reduction mode assists the athlete in either the concentric or eccentric phase of the lift. The IML weighs the bar, and the coach determines what % of the load will be lifted by the forks and in what phase. The force applied by the athlete during the lift is recorded.
In the static and dynamic measurement mode the bar is weighed and the force which the athlete exerts against the load during the lift (both phases) is recorded. Isometric force measurements can also be made.

DISCUSSION
The IML utilizes mechanotronics so athletes can perform free weight exercises with heavy eccentric loads and light, moderate or heavy concentric loads. This training innovation will allow athletes to maximize the quality of their strength training under safe conditions.

CONCLUSION
The IML has much potential for testing and training. Testing will begin in the near future to compare ground reaction force data to IML force data, and to test measurement reliability. An AEL training study is also planned.

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ACUTE PHYSIOLOGICAL AND MECHANICAL RESPONSES TO RESISTANCE EXERCISE PROTOCOLS DIFFERING IN LEVEL OF EFFORT

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INTRODUCTION

Knowledge of the mechanical and physiological aspects underlying resistance training (RT) is crucial to improve our understanding of the stimuli that affect adaptation in order to design safer and more efficient training programs to improve neuromuscular performance [1]. Configuration of the exercise stimulus in RT has been traditionally associated with a combination of the so-called 'acute resistance exercise variables' (exercise type and order, loading intensity, number of repetitions and sets, and rests duration) [5]. Although it is frequently assumed that RT should be performed to muscular failure, increasing evidence shows that training to repetition failure does not necessarily improve the magnitude of strength gains [2,3,4]. Surprisingly, no previous study has examined the effect of manipulating the number of repetitions performed in each set in relation to the maximum possible number of repetitions that can be completed. It seems reasonable that the 'level of effort' (LE) is substantially different when performing, for instance, six out of twelve possible repetitions with a given load -6(12)- compared to performing all possible repetitions -12(12)-, i.e., training leading to repetition failure in each set. Therefore, there exists a need to examine the validity of this concept by analyzing the acute physiological and mechanical response to RT protocols differing in LE.

METHODS

During a period of 8 wk, on different days separated by 48-72 h of recovery, eighteen strength-trained males, ten in the bench press (BP) and eight in the squat (SQ) performed: 1) a test with increasing loads for the individual determination of the 1RM and full load-velocity profile; 2) tests of maximal number of repetitions to failure: 12RM, 10RM, 8RM, 6RM, 4RM; 3) 15 resistance exercise protocols differing in LE: 3x6(12), 3x8(12), 3x10(12), 3x12(12), 3x6(10), 3x8(10), 3x10(10), 3x4(8), 3x6(8), 3x8(8), 3x3(6), 3x4(6), 3x6(6), 3x2(4), 3x4(4), always with 5 min inter-set recoveries. Kinematic data from every repetition in each session was registered by means of a linear velocity transducer (T-FORCE System, Ergotech, Spain) attached to a Smith machine and sampled at a frequency of 1,000 Hz. Acute metabolic (lactate, ammonia post-exercise peak), hormonal (testosterone, cortisol, GH, IGF-1 serum concentrations 5 min post-exercise) and mechanical responses (velocity loss incurred within a set, velocity loss with the ~1 m/s load pre-post exercise and loss of CMJ jump height pre-post) were examined following each type of protocol and compared with the respective baseline values for each variable registered on a different day, in resting conditions, at the same time of day.

RESULTS

The magnitude of the acute response following each of the 15 types of LE for the main variables analyzed is summarized in Table 1. Reductions in the mechanical variables studied were highly and significantly correlated to each other (r = 0.84-0.97). Lactate showed a linear relationship to the LE, both in SQ and BP. Moreover, post-exercise lactate was highly correlated (r = 0.97) with the loss in repetition velocity and CMJ height. Ammonia showed a curvilinear relationship to the LE, increasing from resting levels only when the number of performed repetitions within a set exceeded 50% of the number of possible repetitions. Testosterone showed a linear relationship to the LE and was higher following SQ than BP. The exercise protocols that led to the greatest increases in serum testosterone were 3x12(12) and 3x10(10) in both exercises. These LE were also the ones that induced the highest metabolic stress (lactate and ammonia post-exercise) (Table 1). All types of LE led to increases in GH levels, with values higher than 1000% found for the following protocols: 12(12), 10(12), 8(12), 10(10), 8(8) in SQ; and 12(12), 10(12), 10(10), 6(6) in BP. The magnitude of GH response was clearly dependent on the muscle mass involved in the exercise. Thus, post-exercise serum GH levels were higher for SQ that BP for all levels of effort. Blood lactate and ammonia levels showed a high correlation (r = 0.82-0.91) with serum GH levels following each of the 15 types of LE analyzed.

Protocol	MPV Loss (%)		Lac (mmol/L)		Amo (µmol/L)		hGH (µg/L)		Test (nmol/L)		IGF-1 (nmol/L)	
LE	BP	SQ	BP	SQ	BP	SQ	BP	SQ	BP	SQ	BP	SQ
3 x 6(12)	24,2	20,2	4,2	4,9	45,1	46,3	0,8	4,2	9,3	10,2	31,3	29,9
3 x 8(12)	36,5	32,3	5,7	8,0	53,9	49,1	2,2	7,3	10,9	11,1	29,2	31,0
3 x 10(12)	51,1	37,1	6,7	10,6	70,7	62,0	4,9	9,5	12,0	14,2	27,9	28,9
3 x 12(12)	63,3	46,5	8,2	12,5	106,3	125,8	8,7	17,3	16,8	16,0	30,7	32,3
3 x 6(10)	29,8	22,0	4,6	6,3	46,5	48,3	0,8	2,6	11,3	11,3	22,9	21,3
3 x 8(10)	46,1	32,3	6,0	8,6	63,6	53,9	1,3	5,2	12,4	15,0	25,8	26,9
3 x 10(10)	58,4	45,7	7,8	11,7	89,2	87,8	5,7	9,3	16,8	17,9	31,0	31,4
3 x 4(8)	24,8	21,2	3,4	4,5	48,7	42,3	1,2	2,2	12,2	10,6	25,4	25,9
3 x 6(8)	39,0	29,4	4,8	7,1	54,4	52,3	1,3	3,1	14,1	13,0	24,6	25,2
3 x 8(8)	56,9	39,8	7,5	10,4	79,3	68,9	3,2	7,3	13,1	15,0	27,5	26,7
3 x 3(6)	23,7	19,6	3,1	3,5	51,3	50,9	1,0	0,8	8,3	9,2	26,9	27,6
3 x 4(6)	33,8	28,1	4,0	5,2	52,0	59,6	2,9	5,0	9,7	11,1	26,5	29,3
3 x 6(6)	56,8	41,9	6,9	10,0	68,2	60,3	4,9	6,1	13,5	12,4	33,8	36,9
3 x 2(4)	18,9	16,6	2,6	3,0	45,6	40,9	0,7	3,4	10,6	11,2	24,9	25,7
3 x 4(4)	49,8	31,9	4,9	6,9	53,2	59,1	2,5	6,1	13,5	14,5	25,8	28,5

Table 1 – Mean values of main mechanical, metabolic and hormonal variables analyzed following each type of protocol differing in 'level of effort' (LE). MPV Loss = Loss of Mean Propulsive Velocity within a set (mean of 3 sets), Lac = Lactate, Amo = Ammonia, hGH = Growth Hormone, Test = Testosterone, IGF-1 = Insulin-like Growth Factor-1.

DISCUSSION

Our findings suggest that relative reductions in: 1) MPV within a set, 2) MPV attained with the load that elicits a velocity of ~1 m/s in resting conditions, and 3) CMJ height, all can be considered as similarly precise indicators of the neuromuscular fatigue induced by RT protocols differing in LE when using the most typical intensity range (70-90% 1RM). Furthermore, the blood lactate response to acute resistance exercise can be considered a good indicator of the level of effort performed. The curvilinear relationship of ammonia to the LE suggest that in order to speed up the recovery process between sessions, it is probably not recommended to use the following types of protocols: 12(12), 10(10), 8(8) in SQ; and 12(12), 10(12), 10(10), 8(8) in BP, because they cause ammonia to significantly rise above resting values, which likely indicates an accelerated purine nucleotide degradation and a loss of total adenine nucleotides from muscle.

CONCLUSION

The actual level of effort incurred during resistance training is significantly different when manipulating the number of repetitions performed in each set with respect to the maximum possible number. From a practical point of view, monitoring first repetition's velocity and relative loss of velocity within a set allows us to estimate the real intensity of effort incurred during RT since these variables show a very high correlation to the metabolic fatigue incurred.

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JUMP PERFORMANCE IN 11 TO 18 YEAR OLD AUSTRIAN ALPINE SKI RACERS – A 10 YEAR LONGITUDINAL STUDY

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INTRODUCTION

The evolution of ski equipment has made alpine ski racing for athletes much more dynamic. Carved turns are tighter increasing the centrifugal force on the skier (1). Even young ski racers must develop appropriate power in order to cope with the rigors of racing and training. Williams & Reilly stated that a multidisciplinary approach of anthropometric, physiological and psychological profiling is necessary to determine predictive utilities in talent development (2). In ski racing jumps are accepted methods for power testing (3, 4, 5).

This abstract will focus on gender differences and on generated jump performance norms, which are used to evaluate and prescribe training in young Austrian alpine ski racers.

METHODS

Through cooperation with the Austrian provincial ski teams and Skigymnasium Stams a long term project including anthropometric and physiological tests was founded 1996. In the last decade young athletes (ages 11 to 18 years) underwent the same test battery two/three times annually. The battery consisted of 10 tests; three of which were jump tests.

Counter movement jump (CMJ): CMJ was performed on a Kistler force plate without shoes. Both hands were held on the hips. Each subject performed 3 trials and the highest jump height was recorded. Jump height was calculated by the impulse-momentum method.

Specific Counter movement jump (SCMJ): This ski-specific jump was performed on a Kistler force plate with the subjects wearing ski jumping boots to restrict the ankle joint. The subject squatted down until a 110° knee angle was reached. The subject was then allowed to eccentrically bend deeper, but was not allowed to raise the body before the preload. Hands were kept clasped behind the back for this jump. Each subject performed 3 trials and the highest jump height was recorded.

Drop Jump (DJ): DJ was performed on a Kistler force plate without shoes from a 40 cm high podium. The subjects were allowed to use the arms to generate momentum when jumping. The software identified initial foot contact, takeoff and landing from the ground reaction force data. The jump height was calculated using the flight time of the jump. The reactive strength index (RSI) was calculated by dividing the jump height by the ground contact time. The jump height and contact time of the drop jump producing the highest RSI were recorded.

Differences in longitudinal development in leg power were analysed using a one way ANOVA with Bonferroni Post-Hoc test. Gender differences were made by utilizing an independent t-test (SPSS 15.0). Norm profiles from poor to very good were generated by designating the group means plus/minus 1 standard deviation as average, and 1 standard deviation was used for the width of the other categories.

RESULTS

Significant gender differences of jump tests were found in all age groups except the 12 year olds (table 1). From the age of 15 females showed stagnation in jump performance whereas males increased their jump heights continuously. As age increased RSI showed similar tendencies. This is due to lower jump heights and not due to differences in contact times in females.

Figure 1 shows the CMJ norm profile for boys from 11 to 18 years. A continuous increase from 26.4cm at 11 to 45.9cm at 18 years of age is obvious with a steeper raise from 13 to 15.

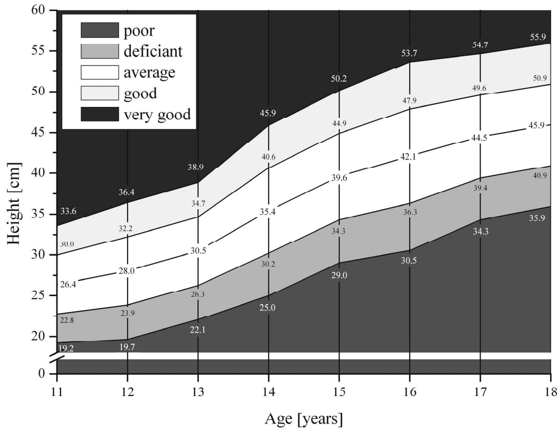
As age increased, CMJ, SCMJ and RSI significantly increased for boys and girls in the analyzed age span ($p< 0.001$). As the boys aged, CMJ and SCMJ increased significantly except when comparing 11 to 12, 15 to 16 (SCMJ only), 16 to 17 and 17 to 18 age groups. In girls CMJ and

SCMJ improved significantly only between 14 to 15 years of age. RSI was significantly different in the 13 to 14 year age group in boys but none in girls.

Table 1. Gender differences of power test in ski racers

Age	Sex	n	CMJ [cm]		SCMJ [cm]		RSI [I]	
11	F	49	25.1±3.2	*	19.5±3.2	*	1.24±0.31	*
	M	61	26.4±3.6		21.0±3.4		1.39±0.40	
12	F	81	27.0±3.9	n.s.	21.4±3.7	n.s.	1.28±0.31	n.s.
	M	102	28.0±4.2		22.2±3.5		1.38±0.40	
13	F	113	28.5±3.5	***	22.7±3.5	***	1.31±0.31	**
	M	130	30.5±4.2		24.6±3.7		1.43±0.38	
14	F	119	29.7±3.9	***	24.0±3.3	***	1.44±0.36	**
	M	145	35.4±5.2		29.5±4.8		1.58±0.38	
15	F	104	31.8±4.4	***	25.7±3.6	***	1.52±0.37	***
	M	119	39.6±5.3		33.9±5.0		1.71±0.36	
16	F	100	32.4±3.9	***	26.5±3.6	***	1.54±0.31	***
	M	107	42.1±5.8		36.0±5.1		1.84±0.31	
17	F	67	31.7±4.2	***	26.3±3.6	***	1.57±0.33	***
	M	90	44.5±5.1		37.7±4.5		1.94±0.35	
18	F	52	31.7±3.7	***	25.6±3.4	***	1.55±0.40	***
	M	76	45.9±5.0		39.2±4.5		2.03±0.34	

Figure 1. Norms of CMJ in male ski racers



F=female, M=male

* p<0.05, ** p<0.01, *** p<0.001,

n.s. not significant

DISCUSSION

In modern alpine ski racing power is more important than ever before, regardless of age. Ski racing is not an explosive sport but the high centrifugal forces which a ski racer encounters to unweight the skis for the next turn requires high power performance. Power testing with different jumps is one facet of the complex fitness evaluation of a ski racer. In Austria this longitudinal fitness test battery with up and coming athletes generates a useful database to support coaches in the talent development process. As expected, the boys jump performances exceed those of the girls. In comparison to published data of CMJ in young soccer (6) or basketball (7) players male ski racers showed a very good leg power performance. Female ski races did not increase jump heights in CMJ, SCMJ and DJ from the age of 16. One could speculate that power did not change from this age due to normal development (body mass increases) but also because of the large volumes of endurance work done by many young Austrian female ski racers. Taylor et al. reported that English females (non-athletes) reached a plateau in maximal jump height with 12 years of age (8). Our findings led to philosophical discussions about long term planning of training for young female ski racers. Better muscular power may allow ski racers to avoid potentially dangerous situations and therefore may be linked to injury prevention.

CONCLUSION

Due to the evolution of ski racing athletes should train intensively for power. Young ski racers dominantly race Slalom and Giant Slalom where a good power performance is more important than in the speed disciplines Downhill and Super G. Moreover in Austria squad selection with young skiers is predominantly based on Slalom and Giant Slalom results. However, this should not lead to young ski racers neglecting other important physical qualities such as coordination, maximal strength, strength endurance or aerobic and anaerobic fitness.

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STRENGTH SKILLS OF SYNCHRONIZED SWIMMERS AT DIFFERENT AGE

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INTRODUCTION

The optimal sport performance in synchronized swimming requires maintaining of swimming strokes technique, earning a certain level of swimming performance and special synchronized swimming technique as well as exact level of gymnastic skills and artistic exhibition [2]. Diagnostics, analysis and understanding the mutual relations of the factors, which belong to the specific structure of sport performance in synchronized swimming are the basic parameters needed for planning a systematic long term training [4]. Newer technological methods make possible to diagnose swimmers' strength by means of special machines e.g. a biokinetic swimming bench Biokinetic TM [1] or a swimming ergometer [3]. During the competition routines the synchronized swimmers perform some of the motion sequences, which can be identified with the trajectory of swimming strokes. The aim of the research was to assess the level and mutual relations of strength skills, monitored on the swimming ergometer in gymnasium and in water of synchronized swimmers at different age. The research was realized within GRANT UK/369/2010.

METHODS

The group involved 21 synchronized swimmers, divided into two groups according to age: 1st group age 17,3 ± 1,7 yrs (n=10), 2nd group age 13,8 ± 1,2 yrs (n=11). In the 1st group there were junior and senior swimmers, among them 8 Slovak representatives, participants at JECH 2009, 2010 and JWCH 2010. The second group involved a selection of younger swimmers. The monitoring of arm strength was realized on swimming ergometer (SE) – it imitated breast stroke during 10s and it imitated three arm strokes during a trust. In gymnasium we used throw with 3kg ball, hold in pull-up and in 25m pool we tested 100 individual medley and a hold in vertical position. We used Speerman correlation to find out the level of statistical significance between the monitored factors and Mann-Whitney U-test to evaluate the relations between the groups.

RESULTS AND DISCUSSION

Regarding the BMI we may state, that the monitored groups in comparison to norms of BMI belong to slightly underweight, that is in accordance with the requirements of sport performance with aesthetic-coordination character. The results in both groups show equal level of swimmers' strength. After the comparison of both groups we found statistical significance of differences in favour of the 1st group in all monitored parameters except for the hold in vertical position. In factor body height, maximal strength of stroke, average and maximal stroke performance and 100 IM (($p<0,01$), in factor body weight ($p<0,05$) and in factor average strength of stroke ($p<0,10$). Some relations between the strength factors were in both age groups statistically significant (Fig.1, Fig.2).

Fig 1 The relations between the monitored factors in the 1st group

	BH	BW	BMI	F1	F2	P1	P2	H	T	100 IM	VP
BH	1										
BW	**0,725**	1									
BMI	0,259	**0,803**	1								
F1	**0,713**	0,475	0,180	1							
F2	**0,679**	0,531	0,241	**0,884**	1						
P1	**0,966**	**0,658**	0,182	**0,687**	**0,723**	1					
P2	**0,880**	**0,696**	0,298	0,486	**0,608**	**0,903**	1				
H	0,037	0,102	0,074	-0,095	0,172	0,018	0,275	1			
T	0,435	-0,049	-0,250	**0,735**	0,406	0,365	0,103	-0,285	1		
100 IM	**-0,691**	-0,420	-0,180	**-0,768**	-0,509	**-0,608**	-0,419	0,500	**-0,719**	1	
VP	0,258	-0,098	-0,401	0,018	-0,116	0,346	0,115	**-0,722**	0,207	-0,340	1

Critical values: ** p < 0,01 (rk = 0,764); * p < 0,05 (rk = 0,631); (*) p < 0,10 (rk = 0,550)

Fig 2 The relations between the monitored factors in the 2nd group

	BH	BW	BMI	F1	F2	P1	P2	H	T	100 IM	VP
BH	1										
BW	**0,883**	1									
BMI	**0,551**	**0,835**	1								
F1	**0,680**	**0,768**	**0,629**	1							
F2	**0,570**	**0,641**	**0,543**	**0,950**	1						
P1	**0,644**	**0,855**	**0,829**	**0,890**	**0,824**	1					
P2	**0,749**	**0,749**	0,510	**0,931**	**0,863**	**0,858**	1				
H	-0,050	-0,165	-0,136	-0,096	-0,068	-0,077	0,068	1			
T	0,463	**0,602**	**0,556**	**0,909**	**0,968**	**0,863**	**0,833**	-0,064	1		
100 IM	-0,346	-0,404	**-0,554**	**-0,560**	**-0,607**	**-0,542**	-0,474	-0,454	**-0,588**	1	
VP	0,214	0,459	**0,727**	0,487	**0,521**	**0,633**	0,387	0,254	**0,588**	**-0,864**	1

Critical values: ** p < 0,01 (rk = 0,734); * p < 0,05 (rk = 0,602); (*) p < 0,10 (rk = 0,519)

legend: BH- body height, BW – body weight, BMI – body mass index, F1 – average force of stroke on SE, F2 – max.force of stroke on SE, P1 – average power of stroke on SE, P2 – max. power of stroke on SE, H – hold in pull-up, T – throw with 3 kg ball, 100 IM – individual medley, VP – hold in vertical position

Following the correlation between the monitored factors in the 2nd group (Fig.2) we may state close relations between BW and BH, between BW and BMI, F1, P1, P2, T, between F2 and P1, P2, T, between P1 and P2, T, between P2 and T, between 100 IM and VP ($p<0,01$). We found statistical significant relations also between BH and BMI, F1,F2,P1, between BW and F2, T, between BMI and F1,F2, T, 100 IM, between F1 and 100 IM, between F2 and IM, VP, between P1 and 100 IM, VP, between T and 100 IM, VP ($p<0,05$). On base of our results we understand that the strength measured on swimming ergometer is in various rate related to the performances in tests of explosive and dynamic force, measured in gymnasium and by special tests in water with respect to each age category.

CONCLUSION

Statistical significance of differences in the level of physical development, between speed-strength skills, explosive force and dynamic force of arms, present certain evolution tendencies of force growth and arm power related to ontogenetic development and length of sport training. Correlation between the monitored force parameters was validated by the close relationships in both age groups. The swimming ergometer in sport training of synchronized swimmers could be useful not only for diagnostics but also as a training means for developing arms' strength.

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COMPARISON OF A FOOTBALL GOALKEEPER'S LOWER LIMBS' EXPLOSIVE STRENGTH

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INTRODUCTION

Implementation of a vertical jump is usually evaluated in three types of execution. The first type is with knees bent with the help of the upper limbs – countermovement jump – free arms (CMJ-F), the next is with knees bent without the support of the upper limbs – countermovement jump (CMJ) and the squat jump without the help of the upper limbs – squat jump (SQJ) [3]. The squat jump is characterized by the lowering of the whole body towards the ground during the initialization phase, subsequent braking movement and acceleration movement in the opposite direction vertically upward. The squat jump without the help of the upper limbs starts from a static position and movement initialization is only in the vertical direction upwards [1]. In the squat jump with the help of the upper limbs, higher values of vertical height are reached, which is the result of both the work of the upper limbs during the take off and following decelerating and accelerating impulses conducted during the lowering of the body and subsequent take off [2].

METHODS

The screened sample was composed of 15 top level players. Age distribution of the monitored individuals was 19.2 to 37.4 years. Those 15 players were tested once, six players from them twice in the last few years and one player was tested four times in a discontinuous time series. The lower limbs strength was scanned by Kistler Force platform (KISTLER Instrumente AG, Switzerland). Monitored participants performed three types of a vertical jump, T1 – CMJ-F, T2 – CMJ, T3 - SQJ. Each participant completed three successful trials of each type of the jump. The best performed trial was chosen for the evaluation.

RESULTS

On the basis of the measured and calculated parameters of three types of take off we may notice that the maximum height of the jump was achieved in the first type when $h_1 = 0.45 \pm 0.03$ m. This result was better by 13.3% (0.06 m) compared to the jump from standing position without the arm support (T2) and by 20% (0.09 m) higher than the squat jump without the arm support (T3). In the first type of the vertical jump, a very important factor is a swing arm work and the use of elastic energy in preload of particular muscle groups caused by the squatting phase (eccentric muscle activity). This is followed by the take off phase (concentric muscle activity). Variance between the best and worst performance, i.e. jump height (h) was comparable in all types of jump implementation ($T1_{var} = 0.11$m, $T2_{var} = 0.12$ m, $T3_{var} = 0.10$ m). The maximum value of the jump height was in $h_{T1} = 0.52$ m, in $h_{T2} = 0.46$ m and $h_{T3} = 0.40$ m.
Decelerating impulse (I1) reached the highest mean value in test T2 ($I1_{T2} = 130.3$ N.s), which is higher by 19 % (24.8 N.s) in comparison to test T1. Strength impulse in the take off phase (I2) was highest in T1 ($I2 = 263.8 \pm 23.9$ N.s), which is more by 6.4 % (17 N.s) than in test T2. Even lower value of the impulse in the take off phase was measured in test T3 (238.2 ± 22.1 N.s). In all types of the vertical jump we noticed shorter times of the braking phase (t_1) compared to the time needed for individual the take off (t_2).
In test T1 we noticed significant variability in both phases of the take off. In the case of the braking phase, variance was $t_{1varT1} = 0.16$ s and in a reflective phase $t_{2varT2} = 0.18$ s. Similar intraindividual variability was found in test T2 at both phases of the take off ($t1_{varT2} = 0.11$, i.e. $t_{2varT2} = 0.16$ s). Highest variance was found in the reflective phase in the squat jump without the help of arms, when $t_{2varT3} = 0.21$ s.

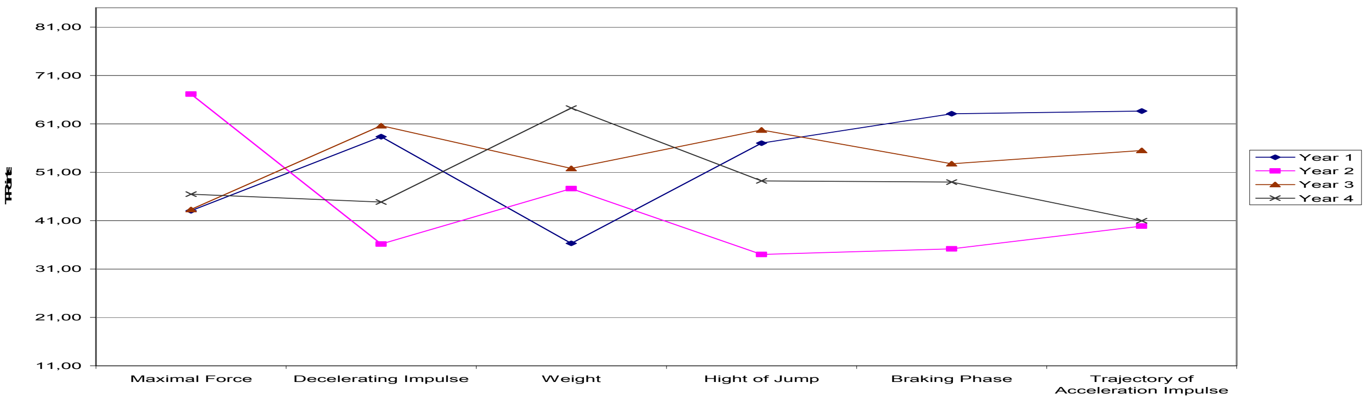

Fig.1 Graphic representation of T-points of selected parameters over four years

To compare intraindividual parameters of a player who was tested four times during disjointed time series we used evaluation by means of T-points. The selected evaluation parameters were the maximum force (Fmax), strength impulse in the take off phase (I2), jump height (h), time of acceleration impulse (t2), trajectory of acceleration impulse (S2) and the body weight of the participant. From the Figure 2 we can assess that, in terms of strength, above the average value was achieved in the second year. Other measurements of this parameter show the strong similarity. Parameters of strength impulse (I2) and jump height (h) indicate that the best results were achieved in both the first and third year whereas the worst result was recorded in the second year. The body weight of the monitored player within those 7 years was 88.3 ± 1.68 kg.

DISCUSSION

In the evaluation of the vertical jump, the absolute reached height is mainly used. In the monitored group these mean values ranged T1 h = 0.454 m, T2 h = 0.401 m and T3 h= 0.362 m. In comparison to basketball players, for instance, they are lower; in the study (Ziv and Lidor 2010) there are values of T1 h= 0.61 m, T2 h = 0.439 m and T3 h = 0.398 m.

In comparison of intraindividual parameters of one player over 4 years we can state that there were very stable results in the most monitored parameters. In the test from the second year, the absolute maximum force (F_{max}) was about 17% above the average for the other years. However, the other parameters showed the lowest values of all measurements. The lowest value of the strength impulse (I2) and the lowest jump height (h) indicate that the player was very well prepared in terms of strength at that time, but the dynamic manifestation of force was, by contrast, suppressed.

CONCLUSION

The results indicate that the screened sample was homogeneous in the measurable parameters and that explosive ability of top level football goalkeepers, in our case the 1st league level, is comparable. Best performances were achieved, in accordance with expectation, in the first type of the jump, it means with the swing of the upper limbs (T1). The results of vertical jump implementation without the upper limbs support (T2) and from squat without the help of the upper limbs (T3) are more comparable, although we could expect that jump implementation with squat could help to higher absolute value of the vertical jump. For the player who was measured during four years we may deduce, on the basis of improving results, that the technique can be improved not only by training and practising, but also by means of experience of previous measurements; goalkeepers can maintain peak performance for a very long time.

This project was supported by the grant MSM 0021620864 and GAČR 406/08/1514.

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Thursday 18:15-19:15

Non-defended Poster Session

MAXIMUM CORE STABILITY IS RELATED TO COACHES' SUBJECTIVE EVALUATIONS OF KENDO PERFORMANCE

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INTRODUCTION

In Kendo, it is thought that possessing good trunk stability is necessary for being a good Kendo practitioner [1,3]. A possible factor that may influence trunk stability may be the stability of the lumbopelvic complex (core stability). Thus, the functions of muscles that control core stability, such as abdominal muscles, may influence not only trunk stability while practicing Kendo but also the Kendo performance itself [1]. Despite the empirically recognized importance of trunk stability, there is no method to quantify the degree of trunk stability while practicing Kendo. Thus, when Kendo masters or coaches evaluate the trunk stabilities of their apprentices, they usually do so subjectively. If core stability is important for stabilizing the trunk while practicing Kendo, it may be possible that there are relationships between objectively measured core stability and subjectively evaluated trunk stability as well as other aspects of Kendo performance. Clarifying this relationship may provide insight into how Kendo practitioners should train their bodies to improve Kendo performance. Thus, the purpose of this study was to examine the relationships between maximum core strength and Kendo performance.

METHODS

Forty-nine college-aged male Kendo practitioners (age, 19.6 ± 1.2 yrs; height, 1.74 ± 0.06 m; weight, 73.9 ± 9.9 kg) with no lower back injuries were recruited for this study. Maximum core strength (MCS) was measured using our custom-made MCS measuring device (Fig. 1a). Initially, participants fastened a belt that interconnected a force transducer and wire around their waists (Fig. 1b). The wire connected to the force transducer is connected to a handle that can be pulled by an examiner. After fastening the belt, participants maintained a prone position with their bodies straight while holding themselves with their elbows and toes (Fig. 1c). In this position, the examiner pulled the handle, and the wire forcefully pulled the belt, extending the lumbar spine of the participant. While the participant maximally resisted against the pulling load, the maximum tensile force in the wire was measured, and we defined this maximum tensile force as MCS

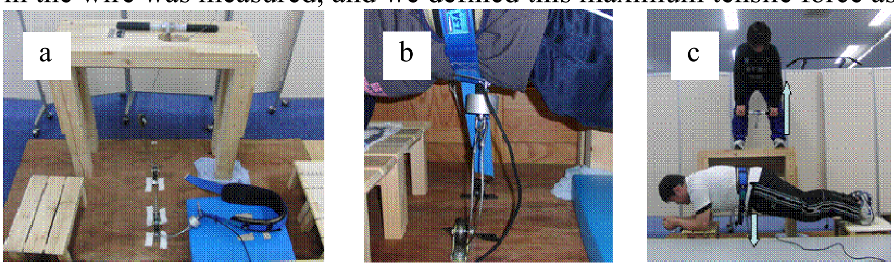

Fig.1 Maximum Core Strength Measurement Device (a), a belt that interconnected a force transducer and wire (b), and MCS measurement scene (c)

Subjective evaluations of the Kendo performance of each Kendo practitioner were performed by 5 highly experienced Kendo coaches (coaches A, B, C, D, and E). Evaluated items included "overall kendo performance (Q1)," "sharpness of strike (Q2), "speed of striking Shinai (a bamboo sword) (Q3)," and "stability of trunk while practicing Kendo (Q4)." Visual analog scales with a range of 0–10 were used to evaluate these items. Pearson's product-moment correlation coefficients were calculated between subjective evaluations for Kendo performance and MCS measurements by each coach. Five separate stepwise multiple regression analyses were conducted to predict the level of MCS by using the 4 subjective evaluations for each coach.

RESULTS

	Q1	Q2	Q3	Q4
coach : A	0.254	0.008	0.087	0.472**
coach : B	0.423**	0.417**	0.457**	0.523**
coach : C	0.378**	0.348*	0.417**	0.309*
coach : D	0.249	0.103	0.144	0.322*
coach : E	0.286*	0.288*	0.270	0.506*

** $p<0.01$, * $p<0.05$

Table 1 Correlation Matrix between Kendo Performance and Maximum Core Strength

Results for Stepwise Regression Analyses

For coaches A, B, D, and E, only Q4 was a significant predictor, explaining 10.4–27.4% of the variance in MCS. For coach C, only Q3 was a significant predictor, explaining 17.4% of the variance in MCS. Regression equations were calculated as follows:

Coach A: $Y_{MCS} = 5.538X_{Q4} + 67.699$

Coach B: $Y_{MCS} = 6.490X_{Q4} + 69.851$

Coach C: $Y_{MCS} = 11.103\ X_{Q3} + 35.890$

Coach D: $Y_{MCS} = 4.370X_{Q4} + 79.061$

Coach E: $Y_{MCS} = 7.259\ X_{Q4} + 58.223$

DISCUSSION

Our results for the simple correlation analyses showed that only subjective evaluations for trunk stability were consistently related to MCS for all coaches, and the results of stepwise regression analyses showed that trunk stability was the only significant predictor of MCS for 4 of 5 coaches. These results indicated that greater trunk stability while practicing Kendo might be related with a greater level of MCS. In Kendo, players collide against each other regularly, requiring them to immediately change direction to ready themselves for subsequent moves. Therefore, sufficient core strength is necessary to maintain trunk stability while practicing Kendo. Our results may in part reflect such physical demands in practicing Kendo, supporting the belief of Kendo practitioners that core stability is necessary to better practice Kendo

The results for stepwise regression analyses were similar among coaches A, B, D, and E, whereas coach C had different results from those of the other coaches. These results indicate the possibility that the subjective evaluation of Kendo performance may depend on the experience and/or cultural backgrounds of individual coaches. In fact, coaches A, B, D, and E are Japanese, but coach C is a New Zealander who practiced Kendo mainly in New Zealand. Thus, it is expected that the experiences and/or cultures shared by coaches A, B, D, and E may by different from those of coach C. Such differences among coaches may have resulted in different points of view to evaluate practitioners, possibly leading to different results.

CONCLUSION

Our study generally supports the premise that core stability is important to stabilize the trunk while practicing Kendo. Implementing core stability training to increase maximum core stability may be beneficial for Kendo practitioners to improve trunk stability while practicing Kendo.

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EFFECTS OF STRENGTH TRAINING WITH PARTIAL VASCULAR OCCLUSION ON SKELETAL MUSCLE HYPERTROPHY AND MYOSTATIN GENE EXPRESSION

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INTRODUCTION

It has been demonstrated that low-intensity strength training (LI, 20-50%1RM) associated with vascular occlusion (LIO) promotes similar gains in strength and muscle mass when compared to high-intensity strength training (HI, >80%1RM) [4, 5, 9]. Increased expression of genes involved in muscle protein synthesis has been observed after acute and chronic bouts of LIO [3] and HI [2]. However, evidence about genes involved in protein degradation after chronic LIO is lacking in the literature. Some studies have found that myostatin (MSTN) is down regulated after a period of HI [7, 8]. MSTN is a negative regulator of muscle hypertrophy playing a key role in the maintenance of muscle mass [6]. MSTN activity is inhibited by some proteins such as follistatin-like-3 (FLST-3), GASP-1, and SMAD-7. We hypothesized that a decrease in MSTN with concomitant increases in FLST-3, GASP-1, and SMAD-7 mRNA expression might be involved in strength and muscle cross-sectional area (CSA) improvements after a period of LIO. Therefore, the purpose of this study was to determine the effect of LI, LIO and HI on strength, muscle hypertrophy, MSTN, and MSTN inhibitors gene expression.

METHODS

Twenty nine male college students, with no experience in strength training were divided into three groups: LI (n=10, 20.3 ± 4.2 yrs, 75.3 ± 15.4 kg, 175.7 ± 4.9 cm, 20%1RM), LIO (n=10, 20.0 ± 4.5 yrs, 72.1 ± 11.9 kg, 175.2 ± 9.0 cm, 20%1RM) and HI (n=9, 23.6 ± 6 yrs, 73.8 ± 12 kg, 173.6 ± 6 cm, 80%1RM). Knee extension 1RM and quadriceps femoris CSA were measured before and after 8 weeks (2x/wk) of bilateral knee extension training. Muscle biopsies from the vastus lateralis were analyzed for MSTN, FLST-3, GASP-1, and SMAD-7 mRNA expression. A mixed models analysis was performed having group (LI, LIO and HI) and time (pre- and post-test) as fixed factor and subjects as random factor. Whenever a significant F-value was obtained a post-hoc test with Tukey's adjustment was performed. Significance level was set at $p<0.05$.

RESULTS

1RM knee extension increased significantly in the LIO (33%) and HI (30.4%) compared to LI (19.3%) ($p<0.05$). Increases in quadriceps CSA were also higher in the LIO (6.3%) and HI (6.1%) compared to LI (2%) ($p<0.05$). It was observed a significant decrease in MSTN mRNA expression in the LIO (45%) and HI (41%) when compared to LI (16%) ($p<0.05$). FLST-3 increased significantly higher in the HI (94%) compared to LI (58%) and LIO (65%) ($p<0.05$). GASP-1 values were significantly higher in the LIO (82%) and HI (79%) compared to LI (23%) ($p<0.05$). There was a significant 86% and 66% increase in SMAD-7 for LIO and HI, respectively ($p<0.05$). (Figure 1)

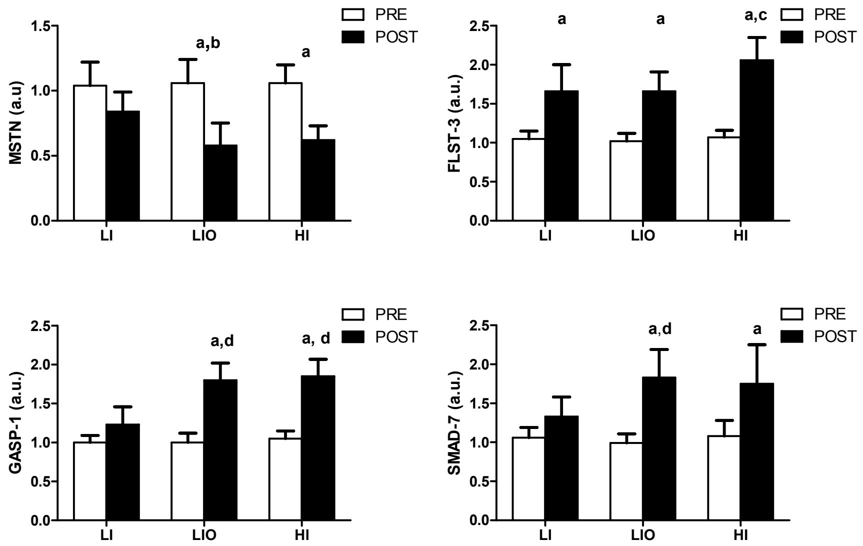

Figure 1- MSTN, FLST-3, GASP-1 and SMAD-7 (a.u.) gene expression (ratio between the mRNA expression of the gene of interest and the internal standard) for the LI, LIO and HI pre and post 8-wk of training (mean ±SEM). [a]post-test different from pre-test, [b]post-test for the LIO smaller than the post test for LI, [c]higher than LIO and LI, [d]higher than LI

DISCUSSION

The primary and novel finding from this study was that MSTN mRNA expression decreased after 8-wk of LIO and HI. In addition, both training regimens resulted in similar strength and CSA improvements. The mechanisms responsible for the positive effects of LIO on strength and muscle hypertrophy are not completely understood. Thus, it is reasonable to speculate that the decrease in MSTN expression in the LIO (45%) and HI (41%) groups may have led to similar muscle hypertrophic response. Roth et al. [7] showed that a 9-wk knee extension exercise training decreased MSTN gene expression by 37% with strength and quadriceps CSA improvements of 30% and 7,5%, respectively. It seems also that greater FLST-3 availability inhibits MSTN signaling, thus maximizing muscle growth [1]. Our results demonstrated that LI and LIO induced similar changes in FLST-3 mRNA levels. We observed an increase in GASP-1 gene expression in the LIO (82%) and HI (79%) groups. The up-regulation of GASP-1 might have contributed to the hypertrophic response after LIO and HI [8]. Finally, SMAD-7 mRNA levels increased in the LIO and HI groups at the end of 8 weeks of training, which might be involved in the attenuation of MSTN activity.

CONCLUSION

In conclusion, 8 weeks of LIO effectively improved functional and morphological muscle changes similar to HI. It is reasonable to assume that the mechanism responsible for such adaptations might involve a decrease in MSTN activity and an up regulation of its inhibitors.

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Acknowledgements: FAPESP (grant no.06/52204-5 and 06/00302-3) and America's Diagnostics S/A (DASA) for technical support on CSA imaging.

RELATIONSHIP BETWEEN MAXIMUM CORE STABILITY AND ISOKINETIC TRUNK FLEXION STRENGTH

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INTRODUCTION

Abdominal muscles are considered important because they play an important role in stabilizing the lumbopelvic complex (Core Stability = CS) [1]. In sports, it is often important to have absolute maximal core muscle strength, especially for athletes who often have to exert explosive power. An established method to quantify maximal CS is to measure isokinetic trunk flexion torque. However, it is unclear whether such maximum isokinetic trunk flexion torque (MTF) also reflects types of maximum core muscle strength such as maximum abdominal muscle strength. The purposes of the current study were twofold: 1) to examine the measurement consistency for our custom-made device to specifically quantify the maximum strength of lumbar spine flexors (i.e., abdominal muscles such as rectus femoris and external/internal oblique muscles) (MCS) and 2) to examine the relationship between MTF and MCS.

METHODS

1. MCS Measurement Consistency

Ten healthy participants (5 men, 5 women; 18.6 ± 0.7 yrs, 1.65 ± 6.6 m, 68.3 ± 8.9 kg) with no history of lower back injuries were recruited from a university student population. Fig. 1 shows our custom-made MCS measurement device. Initially, participants fastened a belt that interconnected a force transducer and wire around their waists. Then, they maintained a prone bridge position, and the examiner pulled the wire to provide a forceful lumber extending load while the maximum tensile force of the wire was measured. This maximum tensile force of the wire was defined as MCS. MCS measurements were conducted twice, and average values were calculated and used for the analyses. The same MCS measurements were repeated twice for each participant within 1–2 days. The intraclass correlation coefficient ($ICC_{2,k}$) was used to evaluate the day-to-day consistency of the MCS measurement.

2. Relationship between MCS and MTF

Twenty healthy active people (10 men, 10 women; 21.9 ± 1.1 yrs, 1.65 ± 8.4 m, 60.1 ± 11.3 kg) were recruited. The MCS measurements were performed as mentioned above. MTF was measured using an isokinetic dynamometer (Fig. 2) per the manufacturer's guidelines, with an angular velocity of 30°/s for 2 sets of 5 repetitions. MTFs were normalized by height (m) and mass (kg), and MCSs were normalized by mass (kg). Pearson's correlation coefficients were used to examine the relationship between MTFs and MCSs.

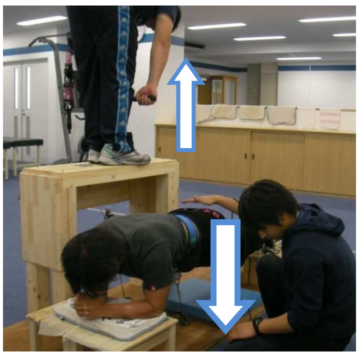

Fig.1 Measurement of Maximum Core Strength

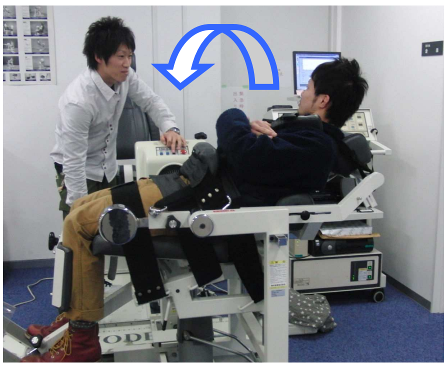

Fig.2 Measurement of Maximum Trunk Flexion

RESULTS

1. MCS Measurement Consistency

Intraclass correlation analysis showed excellent day-to-day measurement consistency for the MCS measurement (Day1: 639.2 ± 127.0 N, Day2: 668.6 ± 161.9 N; $ICC_{2,k}$ = 0.89, SEM = 53.2 N)

2. Relationship between MCS and MTF (Fig. 3)

No significant relationship was found between MCS and MTF (MCS: 11.2±3.6 N/kg, MTF: 3.41±0.78 N/kg; r=0.280, p=0.231).

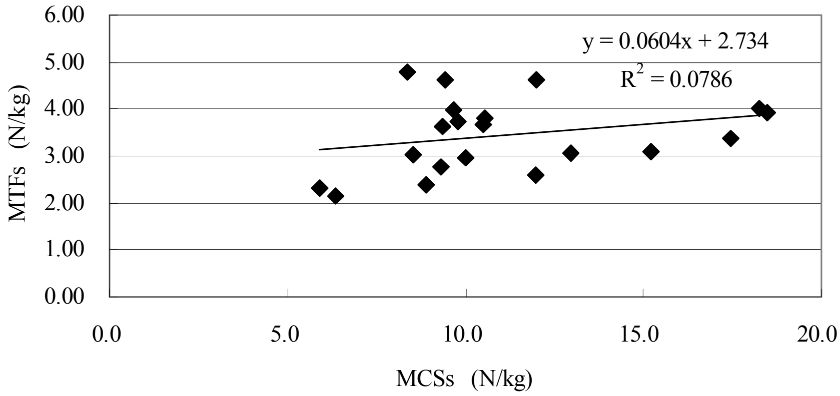

Fig.3 Scatter Plot for the Relationship between Maximum Core Strength and Trunk Flexion Torque

DISCUSSION

Our custom-made MCS measurement device demonstrated excellent measurement consistency. Furthermore, MCS and MTF were not significantly related. These results indicate that our custom-made MCS measurement might provide a unique index to evaluate CS. Our MCS measurement device applies a load to extend the lumbar spine, thus the values from the device might reflect the maximal lumbar spine flexor strength (i.e., abdominal muscles). However, MTF was measured when participants produced maximum hip flexor torque while their trunks were stabilized on the chair of the isokinetic dynamometer [2]. Thus, it is possible that the MTF measurement does not reflect maximum abdominal muscle strength as compared with the MCS measurement.

Our MCS measurements may provide important information, especially for athletes who are required to exert explosive power during games. For example, American football players encounter relatively large external forces that extend their lumbar spines during tackling or pushing against opponents. For those athletes, it may be necessary to understand how they can stabilize their lumbopelvic complex not only to perform powerful tackling or pushing but also to prevent lower back injuries. Our MCS measurement may provide a reliable and appropriate index to evaluate such core stability as compared with currently used submaximal or isokinetic CS measurements [3]. Future research should be directed to evaluate what sport performance the MCS measurement actually reflects.

CONCLUSION

Our custom-made MCS measurement device was shown to provide reliable measurement values. The device may provide a useful and unique index to evaluate maximum core stability, especially for athletes who need strong core stabilities for their sports activities.

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FACTOR STRUCTURE OF INDICATORS FOR EVALUATING LEG EXTENSORS EXPLOSIVE FORCE IN FEMALE

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INTRODUCTION

Adequate preparation of the leg extensors is highly important in many sports disciplines. Values of developed force in the function of time generated during the isometric (static) muscle contraction, with it's own characteristics (F-t curve characteristics) are the fundamental data on contractile ability. Regarding the fact that only a few number of authors examined the specific force parametres [3,5,6] the structure, that is the qualitative relation between indicators for evaluating isometric leg extensors explosive force ($RFD_{LEGExtISO}$) in female population will be examined in this research.

METHODS

In order to assess characteristics of the F-t isometric leg extensors force, tensiometric probe and standardized "seating leg extension" test were used following the earlier described procedures [5]. Sample included 50 healthy and physical active female examinees in various sports. Basic anthropometric data of the tested examinees were: BH=174.66±11.22 cm, BW=67.06±8.62 kg, BMI=22.01±2.42, Age=23.02±4.82 years.The measurement range was defined by 11 variables devided into 3 different dimensions regarding the contractile characteristics of the leg extensors isometric muscle force at the level of 100, 50, 30, 50-100% of maximal force ($F_{maxLEGEXTISO}$), measured following the earlier described procedure [5,6,7,8] – 1) rate of force development analized from the aspect of *absolute values*: the indicators of basic, general ($RFD_{BASICLEGEXTISO}$), specific ($RFD_{50\%LEGEXTISO}$), special ($RFD_{30\%LEGEXTISO}$) level of rate of force development of leg extensors and explosiveness achieved at 50-100% of $F_{maxLEGEXTISO}$ ($RFD_{50\text{-}100\%LEGExtISO}$), 2) rate of force development analized from the aspect of *relative values*: relative values of general $RFD_{allomLEGEXTISO}$, specific $RFD_{allomLEGEXTISO50\%}$ and special $RFD_{allomLEGEXTISO30\%}$ leg extensors rate of force development measured by allometric method, 3) different index parametres; Synergy Index – as a criterion of relation between explosive (RFD) and maximal force at the basic level of 100% of $F_{maxLEGEXTISO}$ – $IndexSNG_{BASIC}$, at the specific level of 50% $IndexSNG_{SPEC}$, at the special level of 30% – $IndexSNG_{SPECIJ}$ of its maximum and Koef S/A gradient as a criterion of relation between explosiveness achieved at 50% and 50-100% of $F_{maxLEGEXTISO}$.

RESULTS

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy showed high statistically significant value of multivariate adequacy in given variables at the level of 0.673, that is 67.3%, while the value of $\chi 2$ Bartlett's Test of Sphericity was 2074.412 at the level of p=0.000. Factor analisys set apart two factors (Table 1), which have explained 96.661% of valid variance.

DISCUSSION

The first factor – specific and special indicator for evaluating explosiveness which explained 67.450% of valid variance is saturated with 7 variables. It described the first part of the Force-time curve, the values of the achieved force in time interval necessary to reach 50% of $RFD_{BASICLEGEXTISO}$, that is, it represents the ability of individual to manifest/show the highest value of specific and special level of rate of force development, or the leg extensors explosiveness, measured at 30% and 50% of $F_{maxLEGExtISO}$ from the aspect of absolute, relative and index values. The participation of the variables in the first factor are as followss: $RFD_{allomLEGExtISO30\%}$ – 0.995, that is 99.5%, $RFD_{30\%LEGExtISO}$ – 0.995, that is 99.5%, $RFD_{allomLEGExtISO50\%}$ – 0.994, that is 99.4%, $RFD_{50\%LEGExtISO}$ – 0.990, that is 99.0%, $IndexSNG_{SPEC}$

– 0.961, that is 96.1 %, $IndexSNG_{SPECIJ}$ – 0.945, that is 94.5%, Koef S/A gradijent – 0.878, that is 87.8 %. (Table 1). In certain sport disciplines high level of explosive force during the initial (early) phase of muscle contraction can be significant for performing explosive moves. The results of previous researches showed the highest differences in specific and special indicators of explosiveness in different muscle groups in regard to different trained population [3,5]. Many authors concluded that the obtained differences in measured values of muscle force between tested trained and untrained population can be explained with differences in muscle tissue and maximal nervous activation of muscles during the specific training, *i.e.* adaptation to specific training [1,2,3,4,5,6]. The second factor – Basic indicator for evaluating explosiveness which explained 29.211% of valid variance is saturated with 4 variables describing the second part of force-time curve, the values of the achieved force in time interval necessary to reasch 50% and 100% $F_{maxLEGEXTISO}$. The variables that participated in defining the second factor are (Table 1): $RFD_{BASICLEGEXTISO}$ – 0.986, that is 98.6%, $RFD_{allomLEGEXTISO}$ – 0.985, that is 98.5%, $RFD_{50–100\%LEGEXTISO}$ – 0.968, that is 96.8%, $IndexSNG_{BASIC}$ – 0.958, that is 95.8%.

Total Variance Explained				Structure Matrix		
Component	Initial Eigenvalues			Variables	Component	
	Total	% of Variance	Cumulative %		1	2
1	7.420	67.450	67.450	$RFD_{allomLEGEXTISO30\%}$	.995	.309
2	3.213	29.211	96.661	$RFD_{30\%LEGEXTISO}$	.995	.329
3	.244	2.221	98.882	$RFD_{allomLEGEXTISO50\%}$	.994	.298
4	.053	.484	99.367	$RFD_{50\%LEGEXTISO}$	.990	.319
5	.027	.244	99.611	$IndexSNG_{SPEC}$	.961	.462
6	.023	.213	99.824	$IndexSNG_{SPECIJ}$	.945	.457
7	.014	.128	99.952	Koef S/A gradijent	.878	-.160
8	.005	.043	99.995	$RFD_{BASICLEGEXTISO}$	.373	.986
9	.000	.004	99.999	$RFD_{allomLEGEXTISO}$	.348	.985
10	.000	.001	100.000	$RFD_{50-100\%LEGEXTISO}$	.188	.968
11	9.085E-6	8.259E-5	100.000	$IndexSNG_{BASIC}$	.291	.958

Table 1. Separated factors with the structural parametres of the explained variance and the Structure Matrix of the observed variables

CONCLUSION

The results of factor analysis of the observed absolute and especially relative indicators (in regard to body mass) for evaluating leg extensors explosiveness showed that separated variables and factors belong to the space that is responsible, from the motor aspect, for realization of the specific technical and tactical requirements, frequent changes of direction in frontal and lateral plane, numerous high and long jumps in different sports.

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ACUTE EFFECTS OF INTENSIVE STRETCHING ON RUNNING SPEED AND POWER IN BASKETBALL PLAYERS

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INTRODUCTION

The influence of stretching exercises performed during a warm-up on speed-strength abilities is a significant issue in competitive sport [1,4]. Stretching exercises were traditionally implemented as a part of a warm-up in order to increase the range of movement around a joint and to improve results or decrease the risk of injuries [1]. However, recent studies suggest that stretching exercises performed before the main motor task do not decrease the risk of injury, and may have a detrimental influence on the strength and speed of a muscle contraction [3]. Thus the verification of the influence of intensive stretching exercises on strength-speed abilities of athletes was the main objective of this work, what seems significant from the empirical and practical point of view. In this experiment an attempt was made to determine the influence of stretching and strength exercises on running speed and anaerobic power in basketball players.

MATERIAL AND METHODS

The research material included a group of 14 well trained basketball players with an average age of 23,2 ± years and training experience equal to 6,8 ± 2,9 years. The protocol consisted of 3 weekly microcycles, each followed by evaluations of running speed (5 and 20m) and lower limb power through a counter movement vertical jump on a force plate. During each microcycle the players conducted 5 specific 2h basketball training sessions, followed by a day of rest and evaluations of speed and power. During week I stretching exercises were performed in the warm-up and cool down and immediately before the tests. During week II no stretching was performed, while in week III dynamic strength exercise were performed at the end of the warm-up and isometric ones in the cool down. The CMJ was performed on an AMTI force plate (AccuGait USA), while speed was measured with the use of a laser device LDM 300C – Sport (Jenoptic Germany).

RESULTS

Six variables describing running speed and lower limb power were considered. The results of pre and post experimental values are presented in tab.1. The take-off speed, jump height, work and power output was significantly higher in the group performing strength exercises. In case of running speed the obtained results differed slightly reaching up to 0.01s and 0.02s for the 5 and 20-meter run respectively.

DISCUSSION

It seems, that intensive stretching exercises performed before dynamic tasks, such as sprinting and jumping, horizontal or vertical have a detrimental effect to performance. The use of isometric tension and dynamic strength exercises directed at lower limbs increases the jumping potential and the development of power. Intensive stretching prior to dynamic exercise most likely decreases the number of actin-myosin crossbridge formation and decreases the stretch reflex, what lowers the speed and force of muscular contraction [2,3]. This experiment confirms the suggestions of many authors who recorded worse results in power and speed trials after intensive stretching exercises, especially prolonged static ones.

Tab. 1. Pre and post experimental values of Speed and Power and the significance of differences under conditions of stretching, strength exercise and the lack of both.

	I		II		III	
	X	SD	X	SD	X	SD
Take-off vel. [m/s] –before	2,8	0,06	2,81	0,073	2,83	0,117
Take-off vel. [m/s] -after	2,8	0,08	2,88**	0,064	2,82	0,119
Jump height [m] -before	0,4	0,03	0,39	0,034	0,41	0,065
Jump height [m] -after	0,4	0,03	0,43**	0,036	0,41	0,062
Total work [J/kg] – before	4,7	0,19	4,81	0,443	4,78	0,553
Total work [J/kg] – after	4,7	0,27	5,20**	0,233	4,84	0,533
Power [W/kg] –before	29,3	1,00	37,14	1,987	36,13	3,418
Power [W/kg] – after	29,3	0,71	39,67**	1,186	36,01	3,804
Start Speed 5m[s] –before	1,36	0,02	1,36	0,022	1,33	0,055
Start Speer 5m[s] - after	1,34	0,02	1,27**	0,031	1,32	0,053
Abs. speed 20m[s] - before	3,48	0,04	3,45	0,034	3,43	0,061
Abs. speed 20m[s] –after	3,45	0,03	3,32**	0,051	3,41	0,060

Significance of differences $p<0,05$* and when $p<0,01$**

I – Stretching, exercises

II – Strength exercises

III – Control, no stretching and strength exercises

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CHANGES IN MAXIMAL FORCE OF BASIC MUSCLE GROUPS IN HANDBALL FEMALE PLAYERS REGARDING DIFFERENT AGE GROUPS CATEGORY – TRANSVERSAL MODEL

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INTRODUCTION

The training system represents long-standing process which involves several permanent cycles. Every cycle has it's own general objective and several special objectives as well, which are logically and functionally connected to general objective of training system – achieving the highest results in senior group [1]. Within the system for observing the physical abilities development, the level of contractile characteristics, in addition to functional abilities, is the main objective of sport metrology [2].The aim of this research is to define model of tendency of changes in maximal force development in female handball players as a result of female handball training system in Serbia.

METHODS

A total of 92 female handball players devided into 4 age groups of seniors – N=20 (Ages 24.3±3.5 yrs, BH=176.1±7.7 cm, BM=69.6±6.3 kg, BMI=22.44±1.20 kg·m^{-2}, training experience=11.5±3.8 yrs; juniors – N=11 (Ages 17.7±0.7 yrs, BH=173.3±6.5 cm, BM=71.3±9.7 kg, BMI=23.68±2.17 kg·m^{-2}, training experience=7.9±1.5 yrs; cadets – N=13 (Ages 15.0±0.6 yrs, BH=172.7±5.9 cm, BM=68.6±6.0 kg, BMI=22.99±1.20 kg·m^{-2}, training experience=5.1±0.8 yrs; and pioneers – N=48 (Ages 13.4±0.5 yrs, BH=168.6±6.5 cm, BM=59.8±8.4 kg, BMI=20.99±2.32 kg·m^{-2}, training experience = 3.8±1.4 yrs were tested. All examinees were members of the best national player teams in their age categories. All tests were performed in the Laboratory of The Republic Institute for Sport and in the Laboratory of Special Physical Education at Academy for Police and Criminalistic Studies in Belgrade by applying the same procedure and measuring device (method of isometric dynamometry). Four muscle groups were tested: left (LHG) and right (RHG) hand grip, legs (standing position) (LEGS) and back-waist extensors (isometric dead lift) (DL). Maximal isometric force characteristics was analysed according to apsolute and relative values. All the results were processed applaying the descriptive statistics and the tendency of changes in the observed contractile characteristics was afterwards defined by applying the method of linear regression using the general equation: $y = ab^x$.

RESULTS

The following models of the tendecy of changes in the observed variables were defined:

Maximal (absolute) values of isometric muscle force results model was -

- $y = 266.60 + 45.25x$, for RHG maximal isometric force, at 91.81% of probability (R^2=0.9181),
- $y = 225.12 + 46.30x$, for LHG maximal isometric force, at 98.89% of probability (R^2=0.9889),
- $y = 632.60 + 185.27x$, for LEGS maximal isometric force, at 94.14% of probability (R^2=0.9414),
- $y = 614.10 + 202.89x$, for DL maximal isometric force, at 95.66% of probability (R^2=0.9566).

Relative values of isometric muscle force results model was:

- $y = 4.5785 + 0.4330x$, for RHG_{REL} relative isometric force, at 98.43% of probability (R^2=0.9843),
- $y = 3.9092 + 0.4696x$, for LHG_{REL} relative isometric force, at 91.44% of probability (R^2=0.9144),
- $y = 10.8460 + 2.3161x$, for $LEGS_{REL}$ relative isometric force, at 99.53% of probability (R^2=0.9953),

- y = 11.1740 + 2.0359x, for DL_{REL} relative isometric force, at 98.50% of probability (R^2=0.9850).

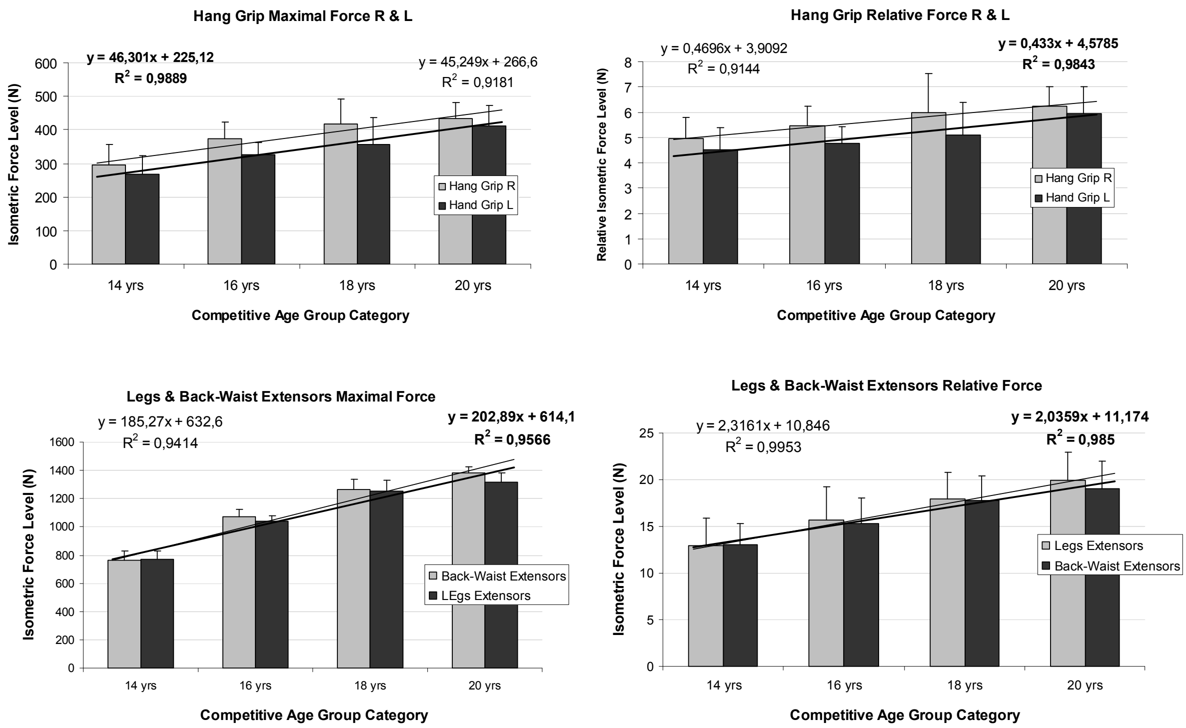

Fig. 1. Defined models of the tendency of change in absolute (maximal) and relative characteristics of isometric muscles force in handball players

DISCUSSION

The results showed the statistically significant (p=0.000) tendency of change in all tested muscle groups, namely in increase of maximal isometric force in:

- absolute values – 45.25 and 46.40 N in right and left hand grip and 185.27 and 202.89 in legs and back-waist extensors, respectively, in regard to 2-years training cycles.
- relative values – 0.4330 and 0.4696 $N{\cdot}BW^{-1}$ in right and left hand grip and 2.3161 and 2.0359 in legs and back-waist extensors, respectively, in regard to 2-years training cycle.

CONCLUSION

The present stydu demonstrate that different muscle groups have different tendency of changes in maximal force development in female handball players during the long period of time as a result of female handball training system in Serbia. At apsolute force values most intensive changes we find at back-waist extensors (average 202.89 N per two yrs period of time) and least we find at right hand finger flexors (average 45.25 N per two yrs period of time). According to relative values most intensive changes we find at legs extensors (average 2.3161 $N{\cdot}BW^{-1}$ per two yrs period of time). Generaly, presented model of tendency of changes can serve as critera for any future sports training technology improvement according to female handballers as well as considering long term planing proces.

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THE EFFECTS OF RESISTANCE TRAINING ON MUSCULAR STRENGTH AND ENDURANCE IN YOUNG JUDOKAS

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INTRODUCTION

Higher demands which characterize modern judo and analysis of many new things in area of periodizations have the aim to enable better training effects and to overcome empiric and disorganized work of coaches by varying different methodical training parameters and characteristic situational judo training. Periodizations of resistance training is performed through following stages: functional adaptation, phase of developing muscular strength and endurance, maintaining phase and compensation phase. The aim of functional adaptation is to prepare muscles, ligaments, strings and ankles for long and tiring training phases. During this phase, athletes exercise 4-6 weeks with loading 40-60% from maximum and repeat cycles 8-12 times in 2-3 series. The next phase develops maximal muscular strength with increasing of muscular endurance. Considering the specifics of judo sport, which has its demands to develop both maximal strength and endurance equally, training should be adjusted. The aim of the maintaining phase is to maintain the levels which are achieved in previous phases. The aim of the compensation phase is to eliminate fatigue and regenerate power source by active relaxation.

METHODS

The research was performed on the sample of 20 selected judokas of cadet age, who ensured its place on the list of potentional competitors in national team for European youth olympic festival (EYOF), European championship and Balkan championship by wining medals on national championship. The estimation of muscular strength and endurance was done by combination of laboratory and field tests. The research was conducted in two phases over the 10- week specially designed training program composed of resistance training and perfecting of specific judo techniques (initial and final test). The laboratory testing was carried out by upper body 30-s Wingate anaerobic test (WanT). For the estimation of muscular strength, field testing for performing functional movements were used: distant jump, triple jump and vertical jump. Muscular endurance was estimated by methods of performing functional movements: push-ups, abdominal strength test (curl-ups) and reverse chin-ups.

RESULTS

The results are presented in table 1 and 2.

Table 1. The estimation of muscular strength of judo athletes (n=20) by laboratory and field testing

Muscular power	Initial test	Final test	p value
Peak power (W)	615,46±62,78	648,14±64,14	$p<0.05$
Peak power ($W \cdot kg^{-1}$)	9,14±1,02	9,63±0,9	$p<0.05$
Distance jump (cm)	209,91±19,3	237,17±19,84	$p<0.05$
Triple jump (cm)	639,72±46,06	651,76±39,4	$p>0.05$
Vertical jump (cm)	47,63±5,7	55,29±7,6	$p<0.05$

Table 2. The estimation of muscular endurance of judo athletes (n=20) by laboratory and field tests

Muscular power	Initial test	Final test	p value
Mean power (W)	446,21±50,52	453,36±49,86	p>0.05
Mean power (W•kg-1)	6,64±0,88	6,73±0,76	p>0.05
Push-ups (repetition)	40,04±7,93	38,94±6,9	p>0.05
Abdominal strength test (repetition)	35,75±4,1	35,76±3,34	p>0.05
Reverse chin-ups (repetition)	14±5,07	15,64±5,1	p>0.05

DISCUSSION

Competitive judo can be described as a combative, high intensity sport in which the athlete attempts to throw the opponent onto his/her back or to control him/her during groundwork combat [1-2]. Both attempts depend on specific techniques and tactical skills with the support of good physical fitness [3]. Given results show statistically significant high values of muscular strength in most tests That is the way how we can conclude that used preparation strength training resulted in increasing the muscular strength of young judokas. Given results show no statistically significant changes of muscular endurance. This response of the body on training won't disturb showing of muscular strength in activities because of anaerobic nature of this activities. However, it is possible that the effect on endurance is shown because of enlarged trainings and decreasing of aerobic capacity on unit of muscular strength. We think that strength training applied in preparation period will lead to adequate increasing of muscular strength of judokas which may make basis for faster performing of movements and efficient performing of techniques during match. Improvement of the aforementioned elements makes competitor's advantage over its opponent.

CONCLUSION

Performing of resistance training as a part of training process of preparation period causes increasing in muscular strength. The competition performance capacity in judo is dependent on several factors among which the muscular strength ones represent only one aspect. The used program can serve as the basis for planning and programming or training process for developing young judokas.

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STRENGTH TRAINING PROTOCOL FOR IMPROVING MOTOR CONTROL EFFECTIVENESS DURING MAXIMAL EFFORT

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INTRODUCTION

Maximal voluntary contraction (MVC) depends on functional capacity of muscle fibers, mainly their size (peripheral level), and on effectiveness of motor control (central level). Obviously, changes in functioning of each level are essentially different during various types of resistive training. Purpose of this work was to develop the training protocol focused mainly on improving mechanisms of motor control during maximal effort, and to evaluate effectiveness of the protocol.

METHODS

12 young physically active male subjects took part in the experiment. Each subject performed maximal isokinetic contractions (165 deg./s) of the right knee extensors 4 times a week for 4 weeks. During training period the number of maximal contractions per training session grew from 50 to 200 repetitions. Relaxation time between repetitions (5-10 s) was sufficient for full recovery of trained muscles. Effectiveness of the proposed training protocol was evaluated by recording knee extensors torques in both legs within angular velocities range from -300 to +300 deg./s several times before, during every week of training and several times after training. Changes were analyzed in three aspects: specificity of training, cross education effects and dynamics of the effects during continuous training. Special parameters of the neuromuscular system at the central (EMG-activity, H- and M-responses) and peripheral (MR-imaging) levels were investigated. In preliminary study lactate concentration during, immediately after and several minutes after a training session were evaluated in parts of participants.

RESULTS

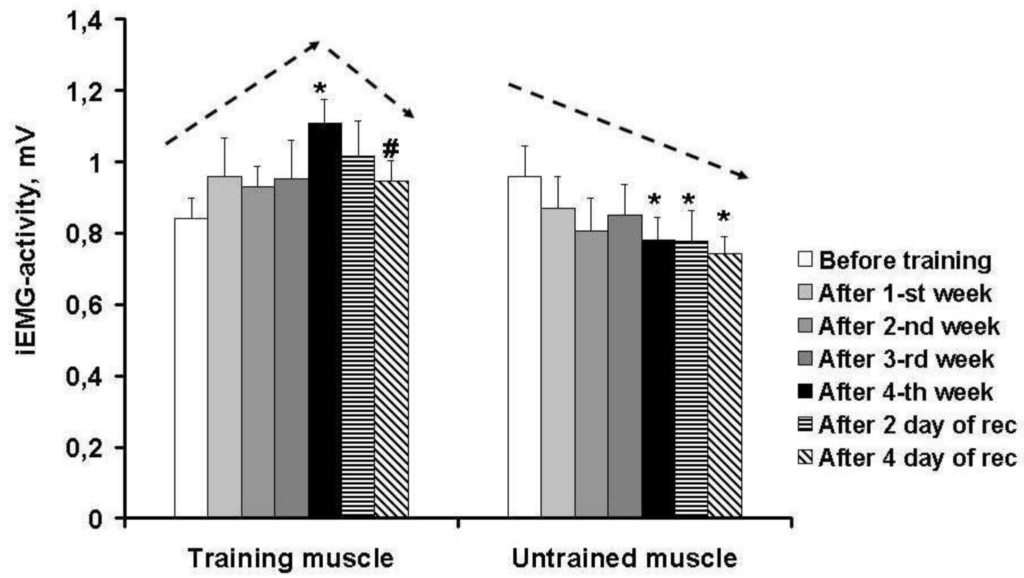

Fig.1. Dynamics of iEMG-activity during and after 4-wk of training for trained and untrained legs. Pre < post training: *$p<0.05$. Post training < 4 day of recovery: # $p<0.05$

The proposed training protocol appeared to be effective for cross education effects. MVC gains in the trained and untrained legs were found to be comparable (up to 15 %). Effects of training specificity were quite evident in relation to contraction modes and, to a lesser degree, to speed values. Analysis of MVC dynamics during 4 wk training period revealed a significant MVC gain already after 1-2 weeks of training and remaining at the achieved level till the end of training. Basic differences in dynamics of iEMG-activity between trained and untrained legs were obtained. Increase of iEMG-activity during the whole training period with abrupt decrease after it for trained muscle, and on the opposite, steady decrease of iEMG-level for untrained muscle group (Fig. 1). Whereas no significant changes of size were found for both trained and untrained muscle groups using MR-imaging technique during training period in two groups. Lactate concentration during, immediately after and several minutes after a training session did not rise above 2 mmol/l. Analyzing of H- and M-responses had a methodological difficulties associated with the close proximity of the investigated muscle groups to the spinal cord. A more detailed discussion of these features is planned to report.

DISCUSSION

Analysis of changes at the central and peripheral levels of neuromuscular system led to the conclusion that the obtained MVC gain was likely to be associated with motor control modification. EMG-activity underwent deep and specific changes. At the same time, neither trained nor non-trained muscles showed a significant change of size. The obtained results may be connected with characteristics of training protocol, which has been chosen to accentuate the activity of central nervous system with minimal damage of muscle fibers. Indeed, number of maximal muscle contractions during 4 weeks of training was almost 4 times more than during 8 weeks of classic training (1). That means the impact on the nervous system was principally greater than during classical strength training. Moreover blood lactate at the end of classical strength training session was shown to be about 5-6 mmol/l (1). As we know from literature glycolytic activation may initiate the development of muscle hypertrophy (2, 3). In the present study lactate concentration during, immediately after and several minutes after a training session did not rise above 2 mmol/l, which was similar to the resting level. As a result no changes of size were recorded in both trained and untrained muscles.

CONCLUSION

The proposed approach to designing strength training protocol may be useful in athletic events which require, on the one hand, development of special motor qualities, and, on the other hand, muscular hypertrophy is a negative factor for achievement of high result.

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ADAPTATION EFFECTS OF EXPLOSIVE WEIGHT TRAINING WITH VS. WITHOUT COUNTER-MOVEMENT

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INTRODUCTION

It has been shown [3] that strength exercise performed with maximal voluntary effort in concentric phase yields better training results than traditional slow lifting typical for body building programs. In addition to maximal effort, further increase of power production during concentric phase can be achieved by involving counter movement. As shown by several authors [1, 2, 4, 6] such an enhancement of power output is due to utilizing elastic properties of the muscle tendon complex and the proprioceptive reflex. The aim of the study was to test the hypothesis whether the strength exercise program consisting of sets performed with higher intensity in concentric phase due to counter movement would yield a different training outcome that the program based on lifting performed also with maximal effort, however without potentiation of power output in concentric phase by counter movement.

METHODS

Thirty physical education students with previous experiences with strength training were recruited for the study. They were randomly divided to two groups. Experimental group (EG) consisted of 14 subjects (age 23.4±1.9 year, weight 77.5±15.1 kg, height 179.2±13.2 cm, control group (CG) of 16 (age 21.9±3.5 year, weight 79.3±16.1 kg, height 180.2±11.2 cm). Both groups trained squats and bench presses 2 times per week for 11 week. In the first week they 3 sets 6 repetition each with 50% of 1RM separated by 2 minute rest period. The training load was progressively increased alternatively by either adding weight (5%) or a set every second week, so that in the eighth week 6 sets 6 reps each with 70 % of 1RM were lifted. The subjects were instructed to apply maximal effort in concentric phase. The only difference between both groups was the time they spent in lowest lifting position. EG performed concentric phase immediately after eccentric one, utilizing counter-movement to potentiate power output. CG performed concentric phase after 2 second stop in the lowest position, avoiding any rebound effect. Prior to and after training period 1RM, maximal power in concentric phase (Pmax) using the maximal effort single reps with increasing weights [5] were carried out. The maximal rate of force development (RFD) from 5 ms interval was also measured in periods 0 – 50 ms, 50 – 100 ms while performing maximal isometric contraction (90 degrees in elbow and knee angle respectively). Statistical analysis was used to determine significant differences between the means by rank method double sided Mann-Whitney and Wilcox t-test.

RESULTS

Initial measurements showed no differences between groups in any of the strength parameter tested. Maximal strength improved in both group and both exercises significantly ($p<0.05$). Bench press 1RM increased in EG from 78.5±17.9 to 85.0±16.7 by 6.5±5.4 kg (8,2 %) and in CG from 90.0±22.9 to 96.7±21.9 by 6.7±5.0 kg (7.3 %). Squat 1RM increased in EG from 100.5±17.3 to 111.0±19.1 by 10.5±5.8 kg (10.5 %), in CG from 102.8±22.8 to 113.7±22.1 by 10.9±5.9 kg (10.6 %). Mean bench press peak power (Fig. 1) in EG group did not change significantly (+2.3 %), however increase in CG from 427.7±80.4 to 437.3±78.8 by 9.6±31.6 (6.4 %) was significant ($p<0.05$). Increases between group were also significantly ($p<0.01$) different. On the other hand, power in concentric phase (Pmax) of squat did not increase significantly in either of the groups (1.7 % in EG and 1.9 % in CG). The maximal rate of the force development (RFD) during initial 50 ms increased significantly ($p<0.01$) in both groups and both exercises: in bench press from 3.44 to 6.73 $N \cdot s^{-1}$ by 3.29±2.5 (95.5 %) in EC and from 4.38± to 7.81± by

3.43±3.09 $N \cdot s^{-1}$ (78.4 %) in CG, as well as in squat from 3.96±1.95 to 6.54±2.90 by 2.57±2.50 $N \cdot s^{-1}$(60.8 %) in EC and from 4.73±2.5 to 7.10±2.0 $N \cdot s^{-1}$ by 2.23±2.40 (50.2 %) in CG. Also maximal RFD in the period from 50th to 100th ms increased significantly in both groups: in bench press from 4.22±1.48 to 7.60±2.22 ($p<0.01$) by 3.29±2.5 $N \cdot s^{-1}$ (80.1 %) in EC and from 3.29±1.03 to 4.55±1.10 ($p<0.05$) by 3.43±3.09 $N \cdot s^{-1}$ (38.4 %) in CG, as well as in squat from 4.14±1.27 to 5.29±1.39 ($p<0.05$) by 1.15±1.31 $N \cdot s^{-1}$(27.8 %) in EC and from 4.44±1.71 to 6.01±2.42 ($p<0.05$) by 1.48±2.17 $N \cdot s^{-1}$ (35.4 %) in CG. However, the increase in bench press was significantly higher ($p<0.05$) in EC (80.1 %) than in CG (38.4 %) (Fig. 2).

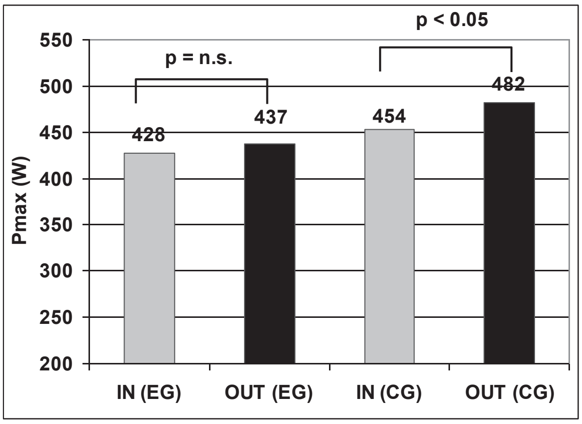

Fig. 1 Bench press mean peak power output before (IN) and after (OUT) 11 weeks training period; (EG) trained with counter-movement, (CG) trained without counter-movement

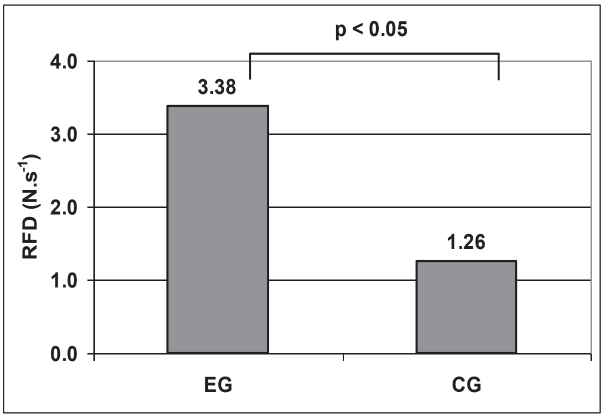

Fig. 2 Bench press mean increases of RFD in the period from 50th to 100th ms while performing maximal isometric contraction; (EG) trained with counter-movement, (CG) trained without counter-movement

DISCUSSION

Conflicting results were found with respect to the influence of two training protocols on power production and RFD. Though power production in concentric phase improved more significantly by exercise without counter movement, counter movement training led to more pronounced and significantly larger increase in RFD, however, only in the 2nd 50 ms period. In addition, such a more pronounced effect was only proved in bench press, not in squat.

CONCLUSION

1. Squat and bench press exercise performed with vs. without counter movement are equally efficient in increasing maximal strength.
2. Exercise without counter movement is more efficient means for improvement of maximal power production in concentric phase.
3. Exercise with counter movement is more efficient means for the improvement of RFD, however, only in the 2nd 50 ms period of maximal isometric contraction.

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ACUTE INCREASE IN SHOT PUT PERFORMANCE AFTER SPRINTING

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Introduction

It is a common practice between athletes competing in track and field throwing events to use specific muscular actions/exercises just before competition in order to acutely enhance their performance. However, there are no scientific data regarding the effectiveness of such interventions. We have recently described an acute increase in throwing performance after drop jumping in moderately trained individuals (Terzis et al. 2009). Aim of the present study was to investigate the acute effect of short-distance sprinting in throwing performance in experienced shot putters.

Methods

Nine experienced shot putters of national level (age 22.8 ± 3 yrs, height 181 ± 7 cm, mass 109 ± 10 kg), performed three trials of the shot put, with maximal effort, with 1-min rest between trials. Then, they rested for 5 minutes and they performed a bout of 30 m sprinting with maximum effort. Approximately 1 min after performing this sprint, they performed three trials of the shot put with 1-min rest between trials, again with maximal effort. Their average and maximal performance before vs. after sprinting was compared with T-Test.

Results

A significant increase was found in the average shot put performance after sprinting (15.20 ± 2.43 m before, vs. 15.70 ± 2.47 m after, $p = 0.00002$). The same result was found when we compared their best performance before vs. after sprinting (15.33 ± 2.41 m before, vs. 15.90 ± 2.46 m after, $p = 0.0007$, Figure 1). Interestingly, shot put performance was enhanced in all of the athletes. A low and nonsignificant correlation was found between individual performance and percentage increase in performance after sprinting.

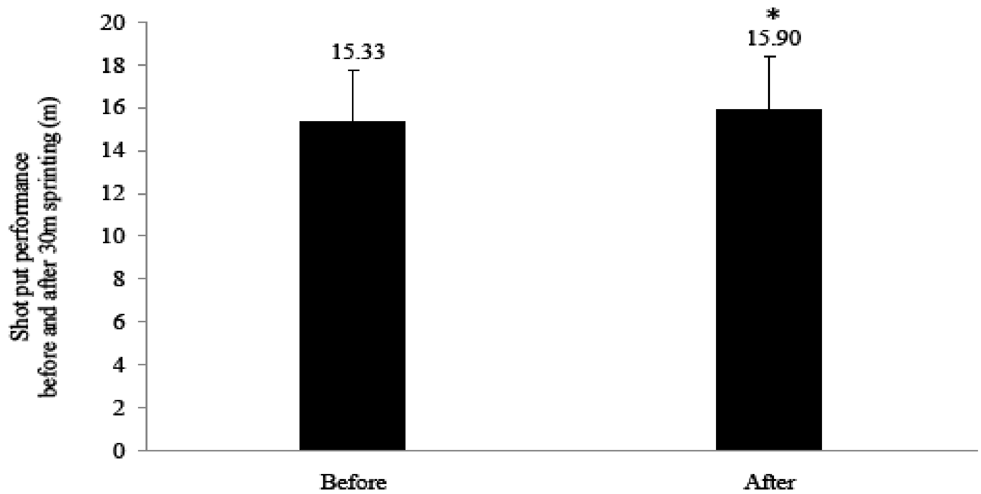

Figure 1. Shot put performance before and after 30 m sprinting, in nine experienced shot putters. * $p = 0.0007$.

Discussion

These data suggest that short-distance sprinting with maximum effort just before performing the shot put has a positive effect on performance in experienced shot putters. This result might be linked with the phenomenon of postactivation potentiation (Hamada et al. 2000). As suggested before, it is plausible that fast and powerful muscular actions, such as during sprinting, might activate type II muscle fibres, thus, enhancing the phosphorylation of myosin light chains in these fibres and subsequently increase the shot put performance in subjects possessing higher percentages of type II muscle fibres (Hamada et al. 2000, Terzis et al. 2009). Interestingly, there are recent reports which show an increased percentage of type II fibers in the thigh muscles of well trained throwers (Terzis et al. 2010, Billeter et al. 2003).

Conclusion

It seems that 30 m sprinting is an effective method for an acute increase in shot put performance in experienced shot putters. Furthermore, it seems that the enhancement in performance is not related with individual performance level which suggests that all shot putters can benefit from such acute intervention.

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NEUROMUSCULAR, CARDIOVASUCLAR, AND HORMONAL ADAPTATIONS TO PROLONGED CONCURRENT STRENGTH AND ENDURANCE TRAINING IN MALE AND FEMALE RECREATIONAL ENDURANCE RUNNERS

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INTRODUCTION Combined strength and endurance training has been shown to improve strength, neuromuscular performance and endurance performance both in high-level [e.g. 2,4,5] and recreational athletes [e.g. 6] as well as young [e.g. 3] and older [e.g. 7] untrained or recreationally active men and women. An interference effect has, however, also been reported when high volume/frequency strength and endurance training are combined [e.g. 1]. The purpose of this study was to examine the effects of strength training, using a combined maximal and explosive strength training protocol, combined with low-intensity endurance training (primarily running) on neuromuscular, cardiovascular and hormonal adaptations in both male and female recreational endurance runners.

METHODS A total of 34 male and female recreational endurance athletes (men, mean ± SD: age, 32.4 ± 8.7 years, height, 178.9 ± 4.9 cm, body mass, 81.4 ± 8.5 kgs and women: age 32.2 ± 7.1 years, height, 166.3 ± 5.8 cm, body mass 61.5 ± 5.9) served in this study including two training periods. First, all subjects performed a 6-week preparatory total body strength training period using loads of 50-70% 1RM combined with low intensity endurance training which consisted primarily of running. Following the preparatory period, subjects were divided into four training groups for an 8-week training intervention. The training groups included a combined maximal and explosive strength-training group consisting of men (M, n = 9), a combined maximal and explosive strength training group consisting of women (W, n = 9), a control group (MC, n = 5) consisting of men and a control group consisting of women (WC, n = 9). Combined maximal and explosive strength training was performed concurrently with the subjects' typical low intensity endurance training (primarily running). The 8-week controlled and supervised training intervention focused on the leg extensors including bilateral leg press, squats (Smith), squat jumps and jumping onto a bench. The control groups performed total-body exercises using only their body weight as a load. All of the training groups kept a detailed training diary throughout the study, recording both strength and endurance exercise. Strength (1 repetition maximum (1RM) and maximal bilateral isometric leg press (ISOM)), muscle activation (surface electromyography of vastus lateralis (VL)+vastus medialis (VM)), power (countermovement jump (CMJ) height), body composition (%fat, InBody) and serum hormonal concentrations of testosterone and cortisol (T and C) were measured prior to the preparatory period (-6 weeks) and at 0, 4 and 8 weeks of the strength training intervention. Endurance performance by VO_{2max} and maximal running speed at VO_{2max} were measured at -6, 0 and 8 weeks.

RESULTS Both experimental groups (M and W) made significant gains in dynamic (1RM) and isometric strength. M made significant improvements in 1RM already during the preparatory training period ($p < 0.05$), which continued during the strength training intervention ($p < 0.01$). W also made significant gains in 1RM strength during the preparatory period ($p < 0.01$) and continued gains throughout the strength training intervention ($p< 0.001$). MC made significant gains in strength following approximately 10 weeks of training (6 weeks of preparatory strength training followed by 4 weeks of the intervention) ($p < 0.05$), as did WC ($p < 0.05$). A similar pattern was observed in maximal voluntary muscle activation of VL+VM during 1RM, however, a significant increase in muscle activation was only observed between 0 and 4 weeks in W ($p < 0.05$). Significant gains in ISOM strength were observed in M between -6 and week 0 ($p < 0.05$) with continued, but insignificant gains during the strength training intervention. W made significant gains in ISOM strength between -6 and week 4 ($p < 0.01$). Both MC and WC made significant gains in ISOM strength between -6 and 4 ($p < 0.05$), however, these gains did not continue during the intervention. Both experimental groups made significant improvements in CMJ height. M showed improvement in CMJ jump height from -6 to 0 ($p < 0.01$) and from 0 to 8 ($p < 0.001$). W also made significant improvements in CMJ jump height, however the improvements between -6 and 0 only showed a trend ($p > 0.05$), while from week 0 to week 8 the improvement was progressive and significant ($p < 0.01$). Following the preparatory period, MC and WC made significant increases in CMJ height ($p < 0.05$), however, during the intervention these improvements did not continue. Significant improvements in CMJ muscle activation were observed only in the experimental groups between -6 and 4 ($p < 0.05$).

Significant progressive improvements in cardiovascular performance were observed in all groups in VO_{2max} (ml/kg/min) ($p < 0.01$) and maximal running speed at VO_{2max} ($p < 0.01$) over the entire training period (-6weeks to week 8).

Significant decreases in body fat % occurred only in our experimental groups ($p < 0.05$). Significant changes in T were observed only in M between -6 and 4 weeks, which was followed by a significant decrease between weeks 4 and 8. No significant changes in C concentrations were observed.

DISCUSSION Combined maximal and explosive strength training performed concurrently with endurance exercise was beneficial for the neuromuscular performance in both men and women. This type of strength training, combined with endurance training, led to significant gains in strength, power and muscle activation while also slightly improving cardiovascular performance measures and body composition. It should be noted that improvements in most variables were more systematic in the experimental groups than in the control groups. This indicates that strength training, including both higher loads for maximal strength development and lower loads (when executing each repetition rapidly) for the development of power characteristics of trained muscles, is more effective than strength training with only body weight as a load even during simultaneous endurance training. No significant gender differences were, however, observed in the development of the neuromuscular performance during the present training period in our recreationally trained endurance runners.

CONCLUSION Combined maximal and explosive strength training added to low intensity endurance training seems to be beneficial for recreational endurance runners.

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TIME SPECIFIC STRENGTH TRAINING INDUCED HYPERTROPHY AND MUSCLE STRENGTH INCREASE OF YOUNG UNTRAINED MEN

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INTRODUCTION

Circadian behavioral and physiological rhythms are driven by autonomous oscillation of clock gene expression and at the core of this timing mechanism is an intricate molecular mechanism that modulate physiological processes in many different tissues throughout the body [1,2]. Experimental studies of correlations between circadian rhythms and sleep disorders or metabolic syndromes confirm complexity character of circadian peripheral regulation and enable us to consider about connection between circadian physiological regulation and time-specific adaptation on physical activity [3,4]. Diurnal variation of sports performance usually peaks in the late afternoon, coinciding with increased body temperature. This typical diurnal regularity has been reported in a variety of physical activities spanning the energy systems,and is evident across all muscle contractions (eccentric, isometric, concentric) in a large number of muscle groups [5]. However, exact mechanisms responsible for time-specific adaptation remain unknown. Souissi et al. [6] summarize that diurnal pattern in maximum strength and anaerobic power might be altered by 6-week time-specific strength training. The increase in strength was greater at the time of day at which the training was conducted than at other times. Sedliak et al. [7] found that 10-week time-specific strength training resulted in similar significant increases in quadriceps femoris muscle volume. However, the actual time-specific training was performed after 10-weeks pre-training period. The purpose of this study was to further investigate effect of time-specific strength training on muscle hypertrophy and muscle strength of knee extensors muscles in previously untrained young men, without any pre-training period.

METHODS

Originally, fourteen previously untrained men volunteered to participate in this investigation, for this part of study only ten subjects were selected and pair-matched (means SD physical characteristics: 23 ± 3 yr, 179.5 ± 7 cm, 83.7 ± 24.3 kg). For time-specific training program (TST) subjects were divided into two groups: Morning (n=5) and Afternoon (n=5) with the training times 07:30-09:00 or 17:00-19:00, respectively. Subjects underwent eleven week of supervised time-specific strength training (TST). Intraindividually oriented strength training program was established on the basis of entering strength testing and modulated on the basis of parallel strength testing. Entering (pre), parallel and final (post) strength testigns of knee extensors were realised on linear motor-powered leg press dynamometer. Functional and morphological adaptations were stimulated with training program oriented to hypertrophy of lower body muscle groups. The structural changes in muscle size, in response to the time specific strength training (TST), were measured before first a week and after the last week of the training program with magnetic resonance imaging technique. Thirty two cross sectional images of femur muscle groups from pre and post testing were obtained, sections no. 6, 9 and 11 (7, 15 and 20 cm from lateral patella) were selected and analysed with OsiriX program. For critical factor we set total cross sectional area of muscle tissue of thigh (MCSA) and maximal power of knee extensors (MPE).

RESULTS

TST resulted in mean MCSA increased non significantly by 9,45 % in the morning group (pre 749,46 cm^2 - post 820,25 cm^2), while the afternoon group showed significant 17,47 % progress (pre 769,67 cm^2 - post 904,17 cm^2; $p<0.05$). Data analysis of single sections hypertrophy indicated significant increase of MCSA by 16,43 % (pre 769,20 cm^2 - post 895,55 cm^2) in 11th

section and non significant results 6,72 % (pre 780,26 cm² - post 832,72 cm²) in 9th section and 4,8 % (pre 698,91 cm² - post 732,48 cm²) hypertrophy in 6th section of morning group subjects. In the afternoon group, analysis of single sections hypertrophy indicated significant results 20,77 % (pre 828,81 cm² - post 1000,95 cm²) in 11th section, 19,04 % (pre 772,70 cm² - post 919,84 cm²) in 9th section and 11,9 % (pre 707,51 cm² - post 791,70 cm²) hypertrophy in 6th section ($p<.05$). Single section analyses are graphically reviewed in Fig. 1. Maximal power of knee extensors indicates similar increase in groups, 13,7 % increase in morning group (pre 185,3 kg - post 210,7 kg) respectively 11,7 % increase in afternoon group (pre 210,1 kg - post 234,7 kg).

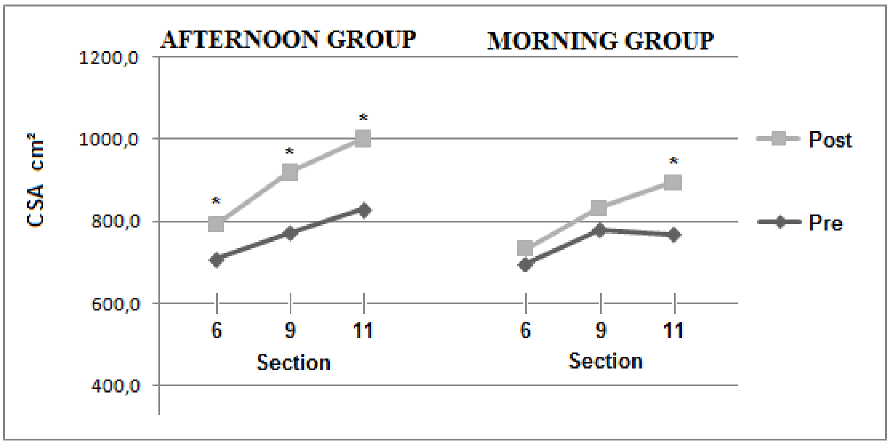

Fig.1 Mean muscle cross sectional area of single sections no. 11, 9, and 6 (* $p<0.05$)

DISCUSSION

The afternoon group had significantly higher total MCSA hypertrophy in comparison with the morning group. Differences between the groups in MCSA correspond with the previously published results [7]. Furthermore, afternoon subjects showed higher homogeneity of hypertrophy process along a muscle, while morning group MCSA increased significantly only in the upper part of a tight (section 11). Selection of exercise devices (leg press) could be one of the reasons behind larger hypertrophy in upper part of tight muscle. Increase in knee extension strength indicates non significant differences between groups and the results correspond with published data [6].

CONCLUSION

The magnitude of muscle hypertrophy after 11-week time-specific strength training indicated significant differences in afternoon group. Interesting finding of potential regional specific hypertrophy difference could be possibly explained with time-delayed hypertrophy processes when training in the morning hours as compared to afternoon. Time-of-day related differences in hormonal levels and (or) neural drive could partially explain the present training-related in muscle hypertrophy. Further research with muscle strength analysis, larger amount of subjects and more frequent parallel testing is needed to confirm significant data results.

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Supported by a grant from Iceland, Liechtenstein and Norway through the EEA Financial Mechanism and the Norwegian Financial Mechanism. This project is also co-financed from the state budget of the Slovak Republic.

THE EFFECTS OF A HIGH FAT DIET ON ANAEROBIC POWER, BODY MASS, BODY COMPOSITION AND ANABOLIC HORMONE PROFILE IN STRENGTH TRAINED ATHLETES

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INTRODUCTION

For many years coaches, athletes and nutrition specialists have attempted dietary manipulations in order to improve physical fitness as well as work capacity and mental abilities. The main reason athletes experiment with the ketogenic diet includes increased fat metabolism and an improved anabolic hormone profile [2,3]. Unfortunately the empirical data on the metabolic effects of a high fat diet and exercise are rather scarce in comparison to carbohydrate loading. Prolonged exercise, fasting, high fat diet and diabetes are the main causes of production of ketonic bodies. The direct cause of ketonic bodies' production is the accumulation of acetyl-CoA and the deficit of oxaloacetate to direct this metabolite to the Krebs cycle [7]. The excess accumulation of ketonic bodies causes a state called ketosis. One must remember that ketonic bodies can be used by the nervous system as an alternative source of energy for glucose [1]. Additionally the ketonic bodies may cause a significant rise in acidity. In competitive sports, in strength-speed sport disciplines the ketogenic diet may be used to reduce or maintain body mass and body fat content. In endurance type sport disciplines a high fat diet may be beneficial in long lasting aerobic (3-4h) continuous exercise of low to moderate intensity, which does not exceed 60-70% $VO2_{max.}$ The main objective of this research was to investigate the chronic effects of a ketogenic diet, rich in PUFA on anaerobic power body composition and anabolic hormone profile.

METHODS

The research material included 10 students practicing power lifting or body building with an average age of 22,6 ± 1,32 years, body mass and body height equaled to 82,3 ± 3,61 kg and 178,2 ± 3,92 cm. The research project had 2 distinct phases, both lasting 6 weeks each. During phase one the athletes consumed a mixed diet with the following proportions of nutrients (CHO–50%, PRO-20% and FAT–30%). In the second phase all athletes were placed on a high FAT diet for 6 weeks, with a predominance of PUFA. The macronutrient proportions were as follows (CHO-15%, PRO-25%, FAT-60%). Before and after each 6 weeks of a specific diet, anaerobic power was evaluated through the 30s Wingate test, body mass and composition were determined with the use of electrical impedance (InBody 220), while blood samples were drawn for the evaluation of anabolic hormones (testosterone, hGH, insulin) and the lipoprotein profile. Capillary blood samples were taken at rest and post exercise to determine LA concentration and acid-base balance. Both diets were isocaloric and provided approximately 3200kcal.

RESULTS

The two applied types of diet, caused no significant differences in body mass and composition in the strength trained athletes except for TBW which was higher in the group consuming a mixed diet ($p<0.05$). The high fat diet did not have detrimental effects on peak power output yet, anaerobic capacity, dependent on glycolisis was significantly lower following the ketogenic diet (Tab. 1). The lipoprotein profile improved significantly on the fat rich diet, composed in 60% of PUFA, while resting levels of testosterone, hGH increased with a drastic drop in insulin concentration.

Tab. 1. The effects of a Mixed and high FAT diet on anaerobic power and capacity evaluated through the 30s Wingate test.

	Mix	Fat	t	P
Pmax (W/kg)	12,43 ± 0,53	12,29 ± 6,40	1,265	0,082
WT (J/kg)	279,3 ± 11,2	266,8 ± 10,4	3,832	0,027 *
LA (mmol/l)	11,94 ± 1,2	10,14 ± 6,83	4,125	0,016 **

Tab. 2. The effects of a Mixed and high FAT diet on lipoprotein profile and the concentration of testosterone, hGH and insulin.

	Mix	Fat	T	P
T Chl (mg/dl)	151,3 ± 16,3	140,2 ± 10,2	2,320	0,065
HDL (mg/dl)	57,2 ± 3,9	64,8 ± 5,4	3,205	0,048 *
LDL (mg/dl)	78,9 ± 6,9	59,6 ± 3,8	4,136	0,029 *
TG (mg/dl)	75,3 ± 9,8	63,3 ±6,7	2,996	0,039 *
Test (ng/dl)	842,2 ± 80,3	973,8 ± 63,1	5,328	0,016 *
hGH (ng/ml)	12,3 ± 3,72	14,21 ± 33	2,853	0,038 *
Insulin (ng/ml)	0,73 ± 0,11	0,42 ± 0,0,09	5,213	0,014 *

DISCUSSION

A ketogenic diet, composed of high quality PUFA, does not hinder max strength and peak power in well trained athletes during intensive training. It may positively influence the anabolic hormone profile what allows athletes under heavy training loads for greater and faster adaptive changes in muscle tissue [4,6]. Anaerobic capacity is significantly compromised by the high fat diet, what is evidenced in this research by a much lower total work output and significantly lower post lactate concentration. All this is most likely attributed to suppressed glycolisis and increased muscle and blood acidosis [5].

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BONE MINERAL DENSITY OF YOUNG WEIGHTLIFTERS WITH RELATION TO THEIR NATURAL DEVELOPMENT

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INTRODUCTION

Regular and systematic physical activity of children and youth has been considered the basic predisposition of harmonious development of the body. Its implementation in the form of well-coached and professionally conducted sports training must correspond to certain criteria according to the principles of sports training of children and youth. The main arguments of specialists preferring involvement of young people in the training process are the benefits of physical activities on the level of primary prevention against civilisation diseases and mitigation of impacts of involution changes. Strength preparation of children and youth is characterised by similar attributes [3] despite the lasting concerns about its negative consequences. Positive effects of strength preparation of youth have been documented by many newer scientific publications [2], [6]. The article submitted is focused on monitoring of changes in the selected parameters of the skeletal system of developing bodies of young weightlifters.

METHODS

The three-year longitudinal research monitoring took place in the sample of young weightlifters (n=16) of the mean chronological age of 12.9 years (9.5 to 16.5 years), mean bone age of 12.6 years (9.2 to 16.2 years), set by means of the TW3 method [5]. The selection criterion and the criterion for remaining in the sample was the requirement of constant participation in the training process. The bone mineral density (BMD) of young weightlifters was determined by means of the Dual energy X-ray absorptiometry (DXA) in the lumbar spine (LS) and proximal femur (PF). The selected diagnostic software (Hologic, Discovery model) allows assessment of changes through BMD increments [$g.cm^{-2}$] and Z-score use in athletes under 20. The measured values were compared to normal values of ordinary population. The lowest significant change (LSC) in waist area was set on 0.044 and in the femoral part on 0.027. The research method determination respected the ISCD recommendations. The assessment of the body growth adequacy was based on the body height changes. In addition to one- and two-year increments, the method of percentile graph and adult body height prediction (based on the regressive equation [4], based on the bone maturation level [5]) were applied. We monitored whether the body height changes copy the predicted trend of young athlete's development. The statistic data processing was based on the confirmed normality of data distribution. The data were assessed by the paired-samples t-test.

RESULTS

The results of medical examinations showed approximately 6.3% mean increment of the BMD after the first year of monitoring and 17.9% increment after two years of monitoring. The BMD assessment in lumbar spine and proximal femur showed statistically significant differences between individual examinations (Fig. 1). This result confirms that changes in the bone mineral density of lumbar spine and proximal femur in young weightlifters are positive and in conformance with the principles of ontogenesis. The assessment of Z-score differences took place with the aim to ascertain changes by comparison of young weightlifters with the normal values of ordinary population of the same age. When testing the Z-score values of lumbar spine, statistically significant differences were found; changes were less evident in proximal femur. A statistically significant difference was found only between the continuous and output measurements.

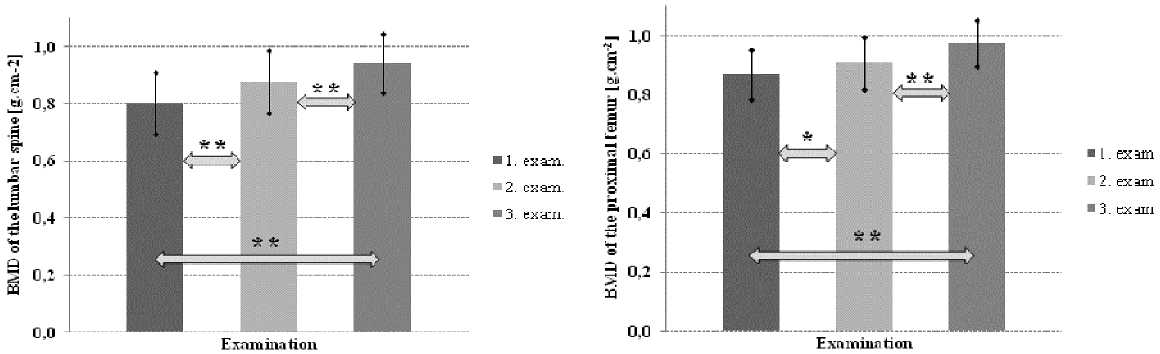

Fig.1: BMD changes in lumbar spine and proximal femur, analysed by means of the pair t-test of the mean value. *p<0.05; **p<0.01

After the intra-individual assessment of changes in the body height of individual members of the sample and considering all the input factors (biologic age, different principles of the methods used, etc.), we concluded that the body height changes in the monitored young weightlifters are in accordance with their natural development. In case of monitoring the body height changes and direction to the predicted adult body height, we have not record any possible negative effects of the weightlifting practice.

DISCUSSION

We state that our results confirm the opinions of experts on the positive effect of strength exercises on the bone tissue in young age. It has already been mentioned that in case of sporting youth, 8-15% increments were recorded within 1-year and 2-year monitoring [3], which undoubtedly correlate with our results. The research results show that during the monitored period, changes in the level of the BMD in waist spine and proximal femur were different (in both the absolute BMD values and Z-score). The reason for this phenomenon can be unequal properties and characteristics of the monitored bones as well as biomechanical differences in loading those body segments that change the dimension of the assumed stimulus. Based on the above results, we suggest supplementing the method of continuous monitoring with the side morphometry of the height of spondyle bodies and the realised analysis of relations between the bone density values and actual load.

CONCLUSION

Based on the above findings we may state that professionally conducted preparation of young weightlifters shows positive results of increasing the mineral density of bones without limiting the natural course of growth. The research results confirmed that the muscular strength, highly specific for this kind of sport, importantly influences the BMD of young weightlifters [1]. Thanks to the parallel monitoring of the body height increments adequacy, we can state that training of young weightlifters in the sensitive stage of their sports preparation is an appropriate stimulus for the development of their skeletal system.

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THREE DIFFERENT INTENSITIES OF A BACK SQUAT FAILED TO POTENTIATE SQUAT JUMPS

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INTRODUCTION

Post-activation potentiation (PAP) refers to a phenomenon where the contractile ability of a muscle is acutely enhanced as a result of a priming exercise (PE) (8). While much of the research on PAP shows improvements in subsequent performance (6,8), there are a number of studies that were unable to find significant improvements (1,2,7). These inconsistent results can be linked to the complex interaction of factors that can elicit PAP including: intensity of load of PE; type of PE; the determination of the optimal timeframe of PAP and the characteristics of participants (5). While optimal conditions for many of the parameters that determine PAP have been established the optimum intensity required to elicit a PAP response has yet to be identified. It has been suggested that loads of 90% 1RM or more are necessary to induce PAP (5) but studies have shown both significant increases in performance (6,9,10,12) and no change in performance (1,4,7,10) when using intensities both above (1,6,7,9) and below (4,10,12) 90% 1RM. The aims of this study were to firstly establish if squat jump height (SJH) can be significantly improved following a PE and if potentiation exists, to establish the optimal intensity for the greatest production of PAP.

METHODS

Ten male participants (mean ± *SD*, age 24.4 ± 3.2 years, mass 81.5 ± 9.4 kg, 1RM 119.7 ± 15.1 kg) with at least one year of experience in performing back squats volunteered to participate in the study. Each participant took part in four testing sessions over a two week period, separated by at least 48 hours. SJH was measured using force plate data (Kistler Type 9286AA, Kistler Instrumente AG, Winterthur, Switzerland) and estimated 1RM was calculated from a 3RM test during session one. Sessions two, three and four were used to test SJH following five minutes of walking recovery from the final repetition of a randomly assigned PE intervention - light squat (LS: 50% 1RM); moderate squat (MS: 70% 1RM) or heavy squat (HS: 90% 1RM). The best score was taken as the result for each intervention and used for further analysis and take-off velocity (TOV) and peak force (PF) were also assessed.

RESULTS

Results revealed no significant effects between all intensities and baseline values for SJH, TOV and PF. Although SJH improved from baseline values for LS (4.9%) and HS (8.9%), but decreased for MS (2.4%), there was no significant effect on SJH between all intensities (F (3,27) = 1.384, p = 0.269, $\eta^2 = 0.133$). The results for TOV follow the same pattern as SJH, where TOV was increased at LS (2%) and HS (3.8%), but decreased to below baseline levels following the MS (1.8%). Again, all intensities failed to cause a significant difference for TOV (F (3,27) = 1.315, p = 0.29, $\eta^2 = 0.127$). Mean PF increased for all intensities from baseline values, although there was no significant effect of intensity on PF (F (3,27) = 2.184, p = 0.327, $\eta^2 = 0.118$). PF also progressively decreased from LS (4.6%) to MS (2%) and MS to HS (0.5%) respectively.

DISCUSSION

Results of the study showed that following a back squat PE at three different loading intensities there were no changes in subsequent performance as indicated by non-significant changes in SJH, TOV and PF. These findings support recent research which also compared the effect of different squat intensities on ensuing performance (3,7,10). The mean increase in performance but large standard deviation in this study provides evidence for high inter-individual differences in the ability to evoke PAP. The mean increase of ~10% in SJH from baseline levels following the HS

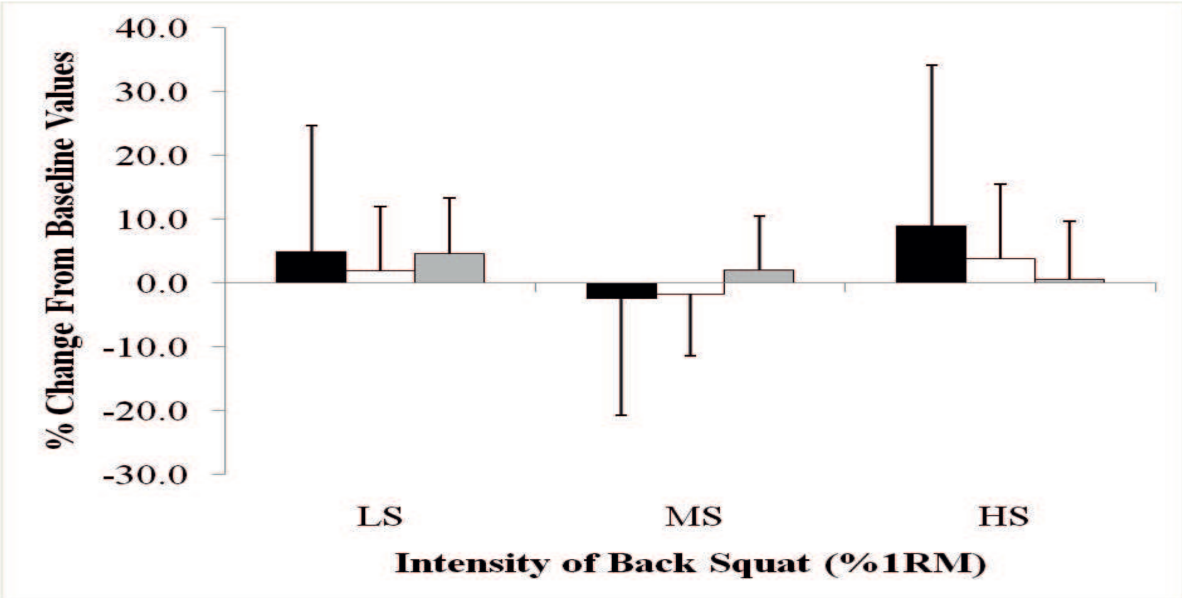

Fig. 1 Percentage change in squat jump height ■, take-off velocity □ and peak force□ from baseline testing during light squats (LS, 50% 1RM), moderate squats (MS, 70% 1RM) and heavy squats (HS, 90% 1RM) interventions (mean ± SD, n=10).

intervention was not statistically significant, yet only a 2.39% increase was reported as significant in the study by Gourgoulis et al. (3). However, there was a low standard deviation for the percentage increase in the aforementioned study, whereas results of the present study show a large individual variation in results. PF showed a tendency towards progressively decreasing from LS to MS and MS to HS respectively suggesting force output may be negatively affected by increasing the intensity of the PE. This is in line with findings from other studies (1,11) who found no evidence of increases in peak force, but did find that rate of force development and peak velocity increased. This would suggest that if a PAP effect is generated, it affects changes in velocity and not force.

CONCLUSION

There was a high degree of variability in results amongst participants, with some experiencing improvements in subsequent performance while others experienced decreases in performance. This shows that PAP is highly individual and may be beneficial for some athletes. There is evidence to both support and refute the existence of PAP, with some athletes benefiting from using this method of training, while others may not due to the highly individual nature of PAP, as exhibited in this study. As such, it is recommended that coaches experiment with using methods to elicit PAP with their athletes.

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EFFECTS OF VIBRATION EXERCISE ON ELECTROMYOGRAPHY ACTIVITY AND RATING OF PERCEIVED EXERTION IN OLDER INDIVIDUALS

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INTRODUCTION

Whole-body vibration (WBV) training has gained considerable attention lately and has been widely used. Published research on WBV training in older adults is increasing and available data seem to indicate on balance [4], and muscle strength [2]. These effects are strongly dependent on the type, frequency, amplitude, and duration of the vibration [3]. Therefore it is important that experimental protocols to control the magnitude of the vibration. WBV is applied through a vibration platform that evokes a mechanical oscillation that can be defined by frequency and amplitude [3]. Greater sEMG amplitudes with higher frequency WBV training (40 & 45 Hz) have been reported when compared to lower frequencies (25 & 30 Hz) [1]. However, to our knowledge no previous studies have measured the surface electromyography activity (sEMG) and rating of perceived exertion (RPE) in community-dwelling older adults. Thus, the aim of this study was to analyze sEMG and RPE responses in different muscles while standing on a vibrating platform producing oscillations of different frequencies and amplitudes.

METHODS

Twenty community-dwelling older adults (79.6 ± 3.2 years) took part in the research. A repeated-measures study design was adopted to assess 12 different vibration treatments (VT) in random order to check the influence of 2 vibration amplitudes (1 mm [low] and 3.1 mm [high]), 3 vibration frequencies (25, 35 and 45 Hz), and the use or non-use of a soft mat on sEMG signal (vastus medialis [VM], vastus lateralis [VL], biceps femoris [BF], biceps brachialis [BB], medial gastrocnemius [MG], lumbar paravertebral [LP], and trapezius [TR]), and RPE when performing static squat exercise on a vibration platform (Fitvibe, GymnaUniphy NV, Bilzen, Belgium). The sEMG value compared with the equivalent baseline (no WBV) half-squat conditions.

RESULTS

Three-factor ANOVA for RPE and sEMG revealed a significant amplitude main effect ($p < 0.05$), and soft mat effect ($p < 0.05$), and a significant frequency main effect ($p < 0.05$) (Table 1).

TABLE 1: Rating of perceived exertion (RPE) and surface electromyography activity (sEMG) at each vibration treatment. Lower body: [VM], [VL], [BF], and [MG]. Whole body: Lower body + [BB], [LP], and [TR] * Significant difference at p <0.05 from high amplitude, same frequency and same soft mat condition. # Significant difference at p <0.05 from `Yes´ soft mat condition, same frequency and same amplitude. & Significant difference at p <0.05 from 25 Hz, same soft mat condition and same amplitude.

Use of soft mat	Frequency (Hz)	Amplitude	RPE	Lower body sEMG (%)	Whole body sEMG (%)
No	25	Low	4.6 ± 1.7 *	174.5±156.1	174.1±113.4
		High	6.0 ± 2.0	237.9±176.0 #	218.9±97.3
	35	Low	4.6 ± 1.7 *	163.1±59.3 *	156.8±31.4 *
		High	7.6 ± 1.7 #&	271.7±135.3 #	261.1±95.9 #
	45	Low	5.0 ± 2.1 *	159.8±57.7 *	153.7±36.4 *
		High	7.9 ± 1.4 &	327.5±194.4 & #	258.0±106.6 &#
Yes	25	Low	3.9 ± 1.4 *	119.7±38.7	123.1±41.1 *
		High	5.4 ± 1.7	166.5±48.8	179.9±58.1
	35	Low	3.9 ± 1.8 *	131.2±32.4	129.4±19.3 *
		High	6.0 ± 1.6	168.5±37.5	181.1±48.3
	45	Low	4.3 ± 1.7 *	152.6± 54.5	144.2±36.0 *
		High	7.1 ± 2.0 &	208.3±137.8	190.4±75.7

DISCUSSION

This is the first study investigating the sEMG, RPE, and their relationship during WBV at different frequencies and amplitudes and on different surfaces in elderly people. Our major findings were that sEMG and RPE increased with the acceleration of the vibration.

In this study the magnitude of the WBV effect was clearly higher with the amplitude high mode (3.1 mm [peak to peak]) than low mode (1.0 mm [peak to peak]) for all muscles, as Hazell et al. [1] have also reported. When using the soft mat the sEMG analyses of all muscles showed conclusive changes with the different amplitudes of High vs. Low (+183.4% vs. +132.2%, respectively). However, without the soft mat there were greater changes, depending on the amplitude, High vs. Low (+161.5% vs. +246.0%, respectively). The mechanism by which the use of the soft mat alters the response to WBV could change depending on the amplitude of the actual vibration when the stimulus is absorbed by the soft material.

CONCLUSION

The results from this study suggest that for progression in training, exercise professionals can increase the training load by altering several variables. Introducing a client at a low frequency with soft mat and a low vibration amplitude represents a reasonable beginning point for older populations. The next step in the progression would be increasing the frequency and removing the soft mat, while keeping amplitude low. One the client is accustomed to this level of stimulus, additional increases in frequency and amplitude could be applied with the soft mat utilized. The final step in this training progression would be increasing the frequency while removing the soft mat at a high vibration amplitude.

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EFFECTS OF VIBRATION TRAINING MODES WITH DIFFERENT FREQUENCIES AND AMPLITUES ON KNEE EXTENSOR STRENGTH

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INTRODUCTION

Vibratory stimulation could elicit reflexive muscle contraction that augment neuromuscular function [1] and contribute to increase flexibility [2]. The protocol of vibration training included frequency, amplitude, and acceleration. By controlling these three parameters, one can adjust the intensity needed for the training [3]. The vibration frequency is the major factor in setting the intensity [4]. Most previous studies compared with the control groups or other training approaches by manipulating a single vibration stimulus. Thus, the frequency and amplitude of vibration training were main factors to training effects, its chronic effects on muscular performance need to further determine. Therefore, the purpose of this study was to investigate effect of vibration training modes such as high frequency low amplitude (HFV), medium frequency and amplitude (MFV), low frequency high amplitude (LFV) and dynamic squatting without vibration (CON) on knee extensor strength.

METHODS

65 health college students (33 males and 32 females, age: 20.08±1.11 years; height: 167.66±9.54 cm; weight: 61.83±11.58kg) were participated different vibration training programs for 8 weeks. The intensity of vibration training groups was set the same at 4g. The training protocol for each group was shown as Table 1. The devices used by the HFV and MFV groups were two different models of vibration platform: Zen^{TM} TVR-6900 and Zen^{TM} -special manufactured (Magtonic Fitness Technology Inc., Taiwan). The LFV group used the Passive Leg Press training machine (PLP machine), which platform was motor-driven. The subjects standing on the platform do rapid muscle contraction passively at a rate which could not be achieved with voluntary strength training [5]. The CON group and three vibration training groups were all asked to do squats at movement frequency of 0.5Hz. There was no stimulus intervention in the CON group. The peak torque of right quadriceps muscles at 60°/s and 120°/s contraction velocity were measured by Biodex system III pro (Biodex Medical System Inc, Shirley, NY) before and after the vibration training. All subjects were asked to do three repetitions in each angular velocity. One minute was given for rest between testing. The two-way ANOVA with mixed design, 4 groups × 2 test sessions, was used by SPSS for Windows 17.0. The level of significance was set at α=.05.

Tab. 1 The protocol of vibration training for four groups

Protocol	HFV	MFV	LFV	CON
Amplitude (mm)	1	3	114	0
Frequency (Hz)	32	18	3	0
Gravity value (g)	4	4	4	0
Duration (s)	60	60	20	60
Resting time (min)	2	2	2	2
Sets per week	4→4→5→5→5→6→6→6			
Squat frequency (Hz)	0.5	0.5	0.5	0.5

RESULTS

The results showed that HFV group significantly improved isokinetic torque about 35.84% at 120°/s (p=.000). The MFV group significantly increased isokinetic torque about 13.75% at 60°/s

(p=.001) and about 13.50% at 120°/s (p=.039), respectively. The LFV and Control groups both not significant difference between pre and post training (p>.05). Moreover, there was no significant difference among groups (*F=.489; p=.692*).

Tab.2 Peak torque of knee extensor changed after 8weeks vibration training

	Group	HFV	MFV	LFV	CON
60°/s (Nm)	pre	138.58±55.32	151.06±46.51	151.17±64.30	134.17±27.72
	post	152.77±64.92	171.96±55.21	160.39±52.77	149.05±35.33
	CP	12.21±30.59	13.75±14.67	9.42±15.99	14.17±29.64
	p-value	.175	.001*	.224	.211
120°/s (Nm)	pre	105.81±60.64	138.08±47.72	134.71±52.16	107.05±42.07
	post	134.01±64.49	152.55±45.49	142.67±51.09	121.97±38.59
	CP	35.84±28.51	13.50±21.67	7.29±18.16	22.44±33.87
	p-value	.000*	.039*	.234	.107

Note: * indicates that significant difference between pre- and post-test. CP is change percentage.

DISCUSSION

In the same g-value, the HFV (32Hz, 1mm) and MFV (18Hz, 3mm) had positive benefit in muscle strength after 8 weeks training. The finding was similar with previous study which found untrained females significant improved knee extensor strength about 24.4%, 5.9%, 8.3%, 7.6% at 0°/s, 50°/s, 100°/s, 150°/s of contraction velocity after 24 weeks of whole body vibration training with 35-40Hz and 2.5-5mm [6]. Most researches pointed out that tonic vibration reflex, TVR, was a major factor to performance improvement through long term vibration training. Upon receiving vibration stimulation, the muscle spindles in the muscle fibers would instantly produce strong excitation signals transmitting in no time directly to α motor neuron fibers in the spinal cord through Ia sensory nerve fibers, that is, through monosynaptic or polysynaptic pathway to recruit motor units for reflex contraction [7]. The frequency and amplitude of MFV group might affected on muscle spindle more than other group, due to the vibration frequency in MFV group was similar with neutral frequency of muscle. It reflected that not only slow-twitch motor units but also fast-twitch motor units were elicited by proper vibration stimulus.

CONCLUSION

The study found that the vibration training modes with different frequencies and amplitudes at the same g-value such as 32Hz & 1mm and 18Hz & 3mm were significant increase knee extensor strength after 8 weeks training. The findings suggested that vibration frequency and amplitude would influence on improvement of muscle strength. The appropriate protocol of vibration training needs to be concern and choice for better training effect.

This study was funded by *Taiwan National Science Council* (NSC 97-2622-B-154-001-CC2). We would also like to express our sincere gratitude to *Magtonic Fitness Technology Inc*. for the equivalent funding and vibration platform.

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THE INFLUENCE OF CORE STABILITY ON KINEMATICS AND PERFORMANCE IN ROWING

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INTRODUCTION

Competitive rowing requires motor coordination and high levels of both strength and endurance. Extreme physiological demands on the rower are further exacerbated by the repetitive, high magnitude forces placed on the flexed lumbar spine; a factor that contributes to low back pain in rowers [6]. In spite of the potential risks to the spine, the ability of the trunk to transfer forces from the legs to the arms is critical to the propulsive force that must be generated to apply forces on the blade in the water [1]. Kinematic studies investigating changes in lumbar spine position at various stroke rates and during routine physiological tests have been measured [4,5], as well as investigations of lumbar spinal motion over a 60 minute period with athletes required to maintain a heart rate between 130-150 beats per minute [3]. These kinematic studies on rowers describe changes in spinal rotations, without hypothesizing about the causes of these changes (i.e., whether postural changes were due to fatigue, technique, flexibility, or condition of the trunk muscles). This study was therefore designed to investigate whether core stability training to improve trunk endurance affords protection against decrements in performance and breakdown of posture. To address this aim, core stability trained and untrained rowers performed a simulated anaerobic threshold training session on a rowing ergometer (3 sets of 15 minutes at anaerobic threshold) in order to determine how trunk endurance related to markers of rowing performance such as leg and arm power characteristics, spine and leg muscle activity, and spinal posture kinematics.

METHODS

Forty-one college-age male and female rowers (21.4±1.1 years) participated in this study, half of whom took part in core stability training and half who did not. Subjects were assessed for isokinetic trunk strength and trunk endurance hold times to determine their trunk strength and endurance, respectively. They also underwent a rowing ergometer step test on the first testing day to determine their relative power output at lactate threshold level, which was estimated to be at $4\text{mmol}\cdot\text{L}^{-1}[\text{LA}^{-}]$. On a subsequent test day subjects completed a simulated rowing training bout of 3 sets of 15 minutes at their individual lactate threshold pace, during which time data for peak power and force at the hands and feet, surface electromyography (EMG) muscle activity of the trunk erector and quadriceps muscles, and 2-dimensional video capture to determine spinal posture kinematics were collected.

Fig 1. Trunk postures at 10% (A), 60% (B), and 95% (C) of the Drive Phase of the rowing stroke. α, β, and χ represent examples of lumbopelvic, lumbothoracic, and hip angles, respectively.

RESULTS

The trunk extensor and flexor endurance test scores were significantly higher in the core stability trained group compared to the group that did not participate in core stability training ($p < .05$). There were no significant differences between the groups for trunk, nor for leg flexion and extension peak torques (N). Both groups showed similar power output at 4mmol·L^{-1} of capillary blood lactate. For rowing power performance, there were no significant main effects for Group or Time across the three sets when comparing the percentage of the rowing stroke (10, 60, or 90%) where peak power, peak force at the hands, or peak force at the feet occurred. Mean EMG activity for both the trained and untrained groups showed no main effects for Group nor interactions for the thoracic or lumbar spinae muscles, although there was a main effect of Time as revealed by a significant decline in EMG activity across the three sets. No significant differences were noted for the vastus medialis or rectus femoris muscles when comparing the three sets of rowing activity.

Spinal posture kinematics showed a significant increase in lumbopelvic angle over time at 10% of the drive phase between Sets 1 and 2 and also between Sets 1 and 3 in the non-trained group ($p < .05$), with no significant changes at 60% and 90% of the drive for either group. Lumbothoracic angles at 10, 60 and 95% of the drive phase showed no significant main effects for Group or Time, and there were not significant interactions ($p > .05$). Hip angle increased significantly over time from Sets 1 to 3 in the non-trained group, but not in the trained group ($p < .05$).

DISCUSSION

A number of studies have investigated kinematic alterations to the spine in terms of trunk curvature changes when rowing for prolonged distances [3], or with high to maximal efforts [2], or during routine physiological tests [5]. None of these studies have considered the role that core stability might play in influencing or reducing postural changes during rowing. Although our findings show that core stability may not be related to prevention of postural breakdown in all positions of the rowing stroke (10%, 60% and 90% of the drive phase) during an interval-type rowing task at anaerobic threshold, posterior lumbopelvic rotation did increase significantly at 10% of the drive phase in the untrained group in comparison to the core stability trained group, which better maintained their lumbopelvic posture at the catch. Hip angle at the finish of the stroke was also better maintained by the core stability trained group, whereas the non-trained group tended to lie back further at the finish of the drive phase, displaying a poor posture known as "slumping". Core stability does not appear to have a significant effect on how power is applied in the rowing stroke in club level rowers. The ability to generate power rapidly at either the feet or hands may be more heavily dependent on different musculature; most likely the legs.

CONCLUSION

Although we did not find that core stability influenced performance or reduced overall decrements in posture breakdown during all positions in the rowing stroke, from a practical point of view it would not be prudent to discard training of the trunk muscles for rowers as core stability training appears to have an influence on reducing lumbar rotation, which might have a positive effect on reducing low back injuries. Further studies are required.

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STRENGTH AND POWER TRAINING AT JUNIOR NATIONAL TEAM IN ALPINE SKIING

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INTRODUCTION

Movement skills are fundamental for the performance in Alpine disciplines; however, the sports performance as such would be impossible without developing specific movement abilities, the two main fitness prerequisites for the performance during Alpine skiing being the aerobic capacity and the muscular strength [7] In downhill skiing, tonic contractions (concentric and eccentric) apply in a vast extend, which causes early local fatigue of the overstrained muscle groups. The vast extent of tonic contraction is also a reason for the high energy exertion and a relatively intensive reaction of vegetatively innervates organs [1] [9].

Strength is defined as the ability to apply force against resistance [2]. The inclusion of strength training for children is a controversial issue. In the past, strength training with supplementary load was not recommended for children for fear of premature stop of bodily growth. However, recent studies [4] [5] show that the risk of damage is low if correct training procedures are followed and the organism of the young sportsmen well prepared. When planning strength training, it is important that the biological, not calendar age is taken into account. Strength training not only helps to avoid injuries, but also provides strong basis for later stages of top level athletes training [4] [6].

The strength and stamina of ski racers are developed mostly by dynamic training. Plyometric training has a positive effect in the building of explosive strength, which is the limiting factor in performance during alpine skiing [8].

The study was aimed at the assessment of the impact of plyometric training on lower limbs explosive strength of a junior Alpine ski team member.

METHODS

The preparation period of a 14-year-old Alpine ski team member was monitored. The sportswoman has trained for 7 years, specializing in Alpine skiing for the last four years. The 17-week preparation period was split into 3 mesocycles with the duration of 6+6+5 weeks. Each mesocycle included special training developing lower limbs explosive strength three times a week, which makes the total of 51 of special trainings sessions designed to develop lower limbs explosive strength included in one preparations period. CYBEX HUMAN NORM dynamometer was used in the laboratory testing of lower limbs flexors and extensors isokinetic strength. The tests were carried at the beginning and the end of the preparation period as well as after 6 and 12 weeks of training.

RESULTS

test / degrees/sec		60 - 5 rep.	180 - 5 rep.	240 - 15 rep.	rel. strength in 240
	leg				
pretest	right	134	77	69	1,28
	left	137	98	81	1,5
posttest	right	159	104	91	1,63
	left	156	107	99	1,77

Table 1.: Cybex human body mesasurement

test / test type (cm)	5 jumps	4 jumps from foot to foot	3jumps at the right leg	3jumps at the left leg
pretest	1023	755	571	568
after 6 weeks	1044	790	584	575
after 12 weeks	1072	805	605	573
posttest	1128	850	610	600

Table 2.: Jumping tests measurement

DISCUSSION

Resistance training was included only as a part of a training camp. The measurements using CYBEX HUMAN NORM dynamometer showed an increase in lower limbs strength in the sportswoman.

The increase in repeated penta-jump by 105 cm after 17 weeks indicates an increase in strength for repeated acyclic locomotion. The same applies to quadri-jump, with an increase by 95 cm. In triple jump, the increase was 39 cm on the right and 32 cm on the left side. [3] in his study states an increase by 12% in penta-jump in sportsmen between 12 and 15 years of age after 6 weeks of plyometric training.

CONCLUSION

Repeated explosive strength of lower limbs is one of limiting factors to the sports performance during Alpine skiing. Plyometric training of junior Alpine ski team member lead to the increase in strength by 5-12,5% in jumping tests and by 9-31,9% in tests using CYBEX HUMAN NORM. We therefore think that the inclusion of special plynometric training at least 3 times a week in the preparation period will result in the developing of lower limbs explosive strength.

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THE EFFECT OF FOOT INCLINATION ON THE BACK SQUAT

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INTRODUCTION

Described as one of the most prevalent strength training exercises, the bilateral back squat is used worldwide [5,7]. Weightlifting shoes are utilised by athletes in both competition and training to aid their performance. It has been suggested that the most important specification of the weightlifting shoes are the height of the heels [3]. The coaching literature suggests that the higher the heel the easier it will be for the athlete to maintain a more upright torso with the correct spinal curvature [2,3]. Previous research has indicated inclines greater than 10° allow the knee joint to travel anteriorly beyond the toes [1], an outcome which is likely to allow a more upright squatting posture. To date there is no published evidence to substantiate the effects caused by smaller inclinations, such as those created by the weightlifting shoe.

METHODS

Motion capture (Vicon MX System, Vicon Motion Systems Ltd, Oxford, UK) data was recorded from 8 athletic male subjects (age 25.5 y ± 4.14; mass 92.61 kg ± 8.01; height 1.849 m ± 0.038; 1 repetition maximum as a multiple of bodyweight 1.57 × BW ± 0.17). A modified Helen Hayes marker set was utilised, with an additional 2 markers attached to the distal aspects of the barbell in order to calculate trunk inclination. All subjects completed 5 repetitions of the back squat across the five foot inclination positions; neutral (N), 4°incline (DI), 2°incline (I), 4°decline (DD) and a 2° decline (D). Subjects lifted a load equal to 50% of their self reported 1 repetition maximum. The order of inclination was randomly assigned and subjects received no feedback. Efforts were made to minimise alterations to the participant's normal training techniques. Data from the first and fifth repetitions were neglected [4]. The bottom positions of each squat (maximum vertical displacement of the bar) were used for further analysis.

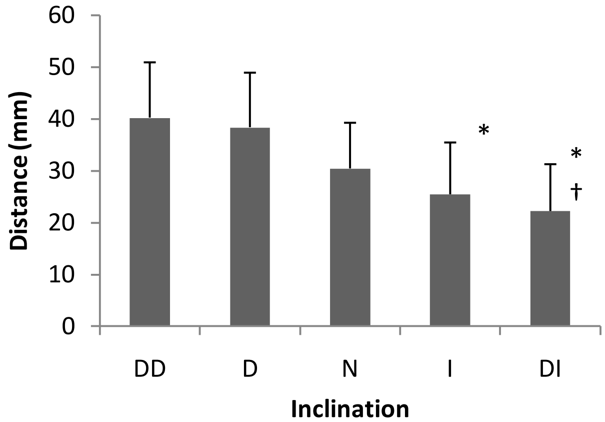
RESULTS

Figure 1 shows the anterior knee translation over the toe for each of the inclinations. A significant effect for knee over toe translation across the five inclinations were found (p<0.05). The contrasts revealed both the DD and D inclinations had significantly more anterior knee translation past the toes than the I and DI inclinations. The N inclination had significantly more anterior knee translation than the DI inclination. A significant effect of inclination on trunk angle was reported (Figure 2, p<0.05). The comparisons revealed the DD inclination caused the subjects to have significantly less trunk flexion/forward lean than the I condition and N condition. At the ankle joint a significant effect of inclination was found (p<0.05). The comparisons showed the DD inclination had a significantly less dorsiflexion than the four other inclinations. The D inclination had significantly less dorsiflexion than the I and DI inclinations. Finally, the N inclination had a significantly lower dorsiflexion than I inclination and DI inclination. The findings indicate as the inclination increases the level of ankle dorsiflexion decreases.

DISCUSSION

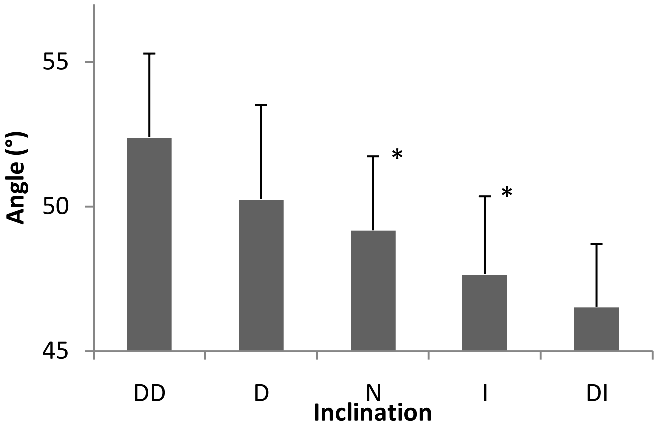
This study focused on minor adjustments to declination; despite the differences in declination the findings are similar to previous research [1]. The current findings indicate utilising a heel lift allows the knees to move anteriorly beyond the toes, permitting forward translation of the hip and therein allowing a more upright trunk position at the bottom of the squat. This finding is supportive of previous work [6] which demonstrated increased forward trunk lean when knee translation was restricted which might inappropriately load the structures of the spine.

In order to allow for correct positioning of the torso and appropriate loading at the joints Fry et al. (2003) suggest permitting the knees to move beyond the toes. This study has shown that utilising a weightlifting shoe during the squat places the lifter on a decline allowing the knees to move anteriorly beyond the toes with less demand placed on ankle range and a more upright posture at the bottom of the squat. It has previously been shown when the ankle is restricted the knee is unable to flex maximally without a decline [8]. A reduced demand for ankle range might also reduce the tendency for pronation and so enhance squat stability, although this requires further investigation.



*Sig. difference between inclination and DD inclination and D inclination $p<0.05$, †Sig. difference between inclination and N inclination $p=0.000$

Figure 1: Group mean ± SD for anterior knee translation beyond the toes for each inclination.



*sig. difference between inclination and DD inclination $p<0.05$

Figure 2: Group mean ± SD for trunk angle under each inclination condition.

CONCLUSION

Athletes who are limited by their ankle flexibility or ankle joint stiffness and can not meet the increased dorsiflexion requirements may benefit from utilising a heel lift as provided by weightlifting shoes. The use of a weightlifting shoe to increase the level of heel lift may allow an athlete to achieve a greater squat depth whilst maintaining a more upright posture and therein protect the passive structures of the spine. Further research is needed to quantify the joint kinetics and kinematics at the ankle, knee, hip and trunk.

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POWER IN CONCENTRIC PHASE OF CHEST PRESSES WHILE LIFTING DIFFERENT WEIGHTS UNDER STABLE AND UNSTABLE CONDITIONS

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INTRODUCTION

Instability resistance exercises have proved effective improvement on neuromuscular performance in rehabilitation and in prevention of injuries. On the other hand, there is a lack of information on the effect of these exercises on athletic performance.
Cowley et. al (2007) found [1], that instability training was to be equally or less effective in improving athletic performance. One of the studies [2] documented reduction rates about 10 % in power during dynamic resistance exercise under unstable conditions.
However this effect may depend on weight lifted and therefore the aim of the study was to compare power in concentric phase of chest presses while lifting different weights under stable and unstable conditions.

METHODS

A group of 12 PE students (age 24.7 ± 2.8 y, height 180.9 ± 4.7 cm, and weight 78.6 ± 4.1 kg) performed 3 repetitions of barbell chest presses on bench and on Swiss ball, respectively. Exercises were performed in random order with previously established 40, 60 and 80% of 1RM. A PC based system FiTRO Dyne Premium was used to monitor force and velocity and to calculate power. Maximal and mean power (Pmax, Pmean) and power in acceleration phase (Paccel) were analyzed.

RESULTS

Results showed significantly ($p < 0.01$) higher power in acceleration phase of chest presses under unstable than stable conditions at 40% of 1RM (592.7 W and 520.3 W, respectively) and 60% of 1RM (559.5 W and 479.4 W, respectively). On the other hand, there were no significant differences in chest presses at 80% of 1RM (447.7 W and 401.7 W and, respectively). **(Fig.1)**
However, no significant differences were found in maximal power under both conditions with all weights lifted, at 40% of 1RM (771.4 W and 748.6 W, respectively), at 60% of 1RM (740.8 W and 690.6 W, respectively), and at 80% of 1RM (588.0 W and 571.5 W, respectively). **(Fig.2)**
Likewise, there were no significant differences in mean power at 40% of 1RM (367.8 W and 365.9 W, respectively), at 60% of 1RM (403.0 W and 390.9 W, respectively), and 80% of 1RM (361.7 W, 349.7 W, respectively). **(Fig.3)**

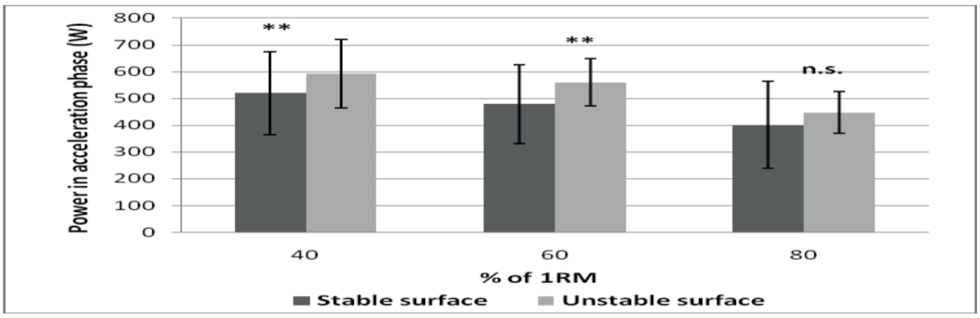

Fig. 1 Power in acceleration phase of chest presses with different weights lifted under stable and unstable conditions (** p<0.01)

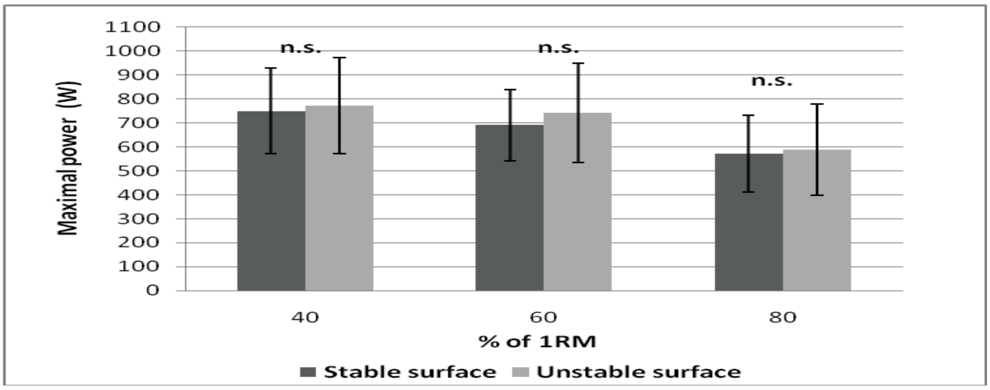

Fig. 2 Maximal power in concentric phase of chest presses with different weights lifted under stable and unstable conditions.

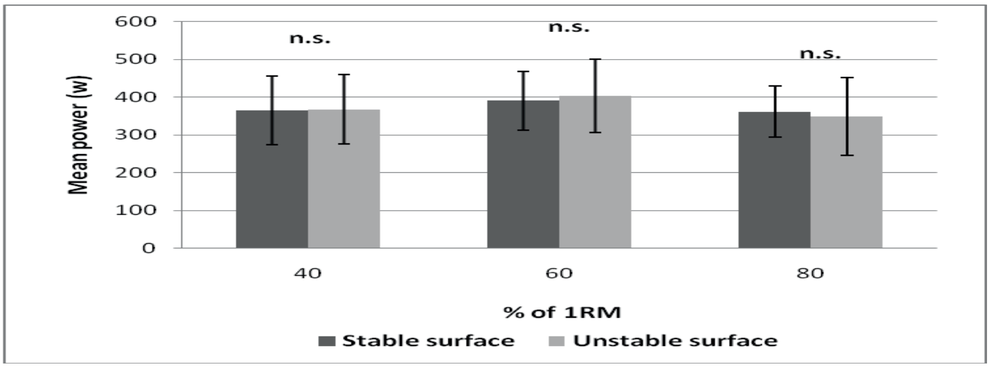

Fig.3 Mean power in concentric phase of chest presses with different weights lifted under stable and unstable conditions.

DISCUSSION

Higher power in acceleration phase of chest presses at 40% and 60% of 1RM was (12.2 % and 14.3%, respectively) on unstable surface. Only slight differences has been found in mean a maximal power and at 80% of 1RM in acceleration phase This finding is in disagreement with a previous study [2], that showed lower power in chest presses over 10% under unstable conditions at 50% of 1RM. Has been found, that well trained subjects achieved similary power outputs between stable and unstable conditions.

CONCLUSION

Power in acceleration phase of chest presses is higher on unstable than on stable surface however only at 40% and 60% of 1RM. In parameters Pmean, Pmax, 80% of 1RM was found no differences. Exercises on unstable surfaces do not have a negative effect on power produced during chest presses.

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The effect of mental and physical practice on muscle electrical activity in force production task

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Introduction

Despite the fact that several decades have passed from the date of introduction of mental practice as one of the effective methods of motor learning development, day after day new findings are reported in this field of study and new aspects of mental practice are dealt with. The researches done in the past decades not only have shown that mental practice, like physical practice, develops motor skills (Feltz & Landers, 1983), but also have proved that the learning mechanisms that contribute in physical practice are activated in mental practice tool (Barr & Hall 1992, Bonnet et al, 1997). Some researchers such as Yaguez et al (1998) have shown that mental practice, like physical practice, is effective in motor skills learning but some others emphasize that the role of mental practice in motor learning is less than that of physical practice (Jackson et al, 2004). Some other researchers believe that mental practice has no bearing on motor learning (Mulder et al, 2004; Ryan and Simons, 1982). In the latter case Hall (1992) holds that the inefficacy of mental practice on motor learning is due to incorrect mental practice. He believes that a false imagination of an activity results in negative effects rather than positive ones (Hall et al, 1992).

Methods:

Participants

This is a fundamental research and in terms of method it is semi-experimental. Data was gathered in the laboratory. 5 groups (4 experimental groups and one control group) participated in the research including practice intervention, pre-test, acquisition test, retention test and transfer test.

The subjects included 75 female students selected from the population through simple random sampling method. The subjects had no experience in the task and were unaware of the research objectives before participation in the practical task. All the subjects were right-handed. All the participants filled out questionnaires including individual information (age, height, weight, etc.), medical information (record of illness, pain, surgery in shoulders, wrists and elbow, damages to muscles due to grabbing and also mental and muscular diseases) and sports record.

The participants were randomly divided into 4 groups: physical group (15 persons), integrative group (15 persons), control group (15 persons) and the remaining 30 persons were divided electively and purposively into vague mental practice group (15 persons of the participants with the lowest scores in the tests) and clear mental practice group (15 persons with the highest scores in the tests).

Statistical Analaysis

Descriptive statistics was used to determine indices, deviation, data display, data categorization in terms of suitable parameters and drawing curves and diagrams. The normality of data was tested using Knowledge-Smirnov test. T-test for independent groups was used to compare the pre-test results and acquisition, retention and transfer tests results. Variance analyses were used to compare the difference in the means of different groups (in terms of significance). Tukey's test was used to determine the difference among the groups and the group with the highest progress.

Results

Fig. 1 shows a summary of performance means of the study groups at pretest, acquisition, retention and transfer stages in all the five groups. As fig. 2 shows the best performance in all the stages is related to physical practice group. On the other hand, vague practice group has an unnoticeable progress similar to that of the control group.

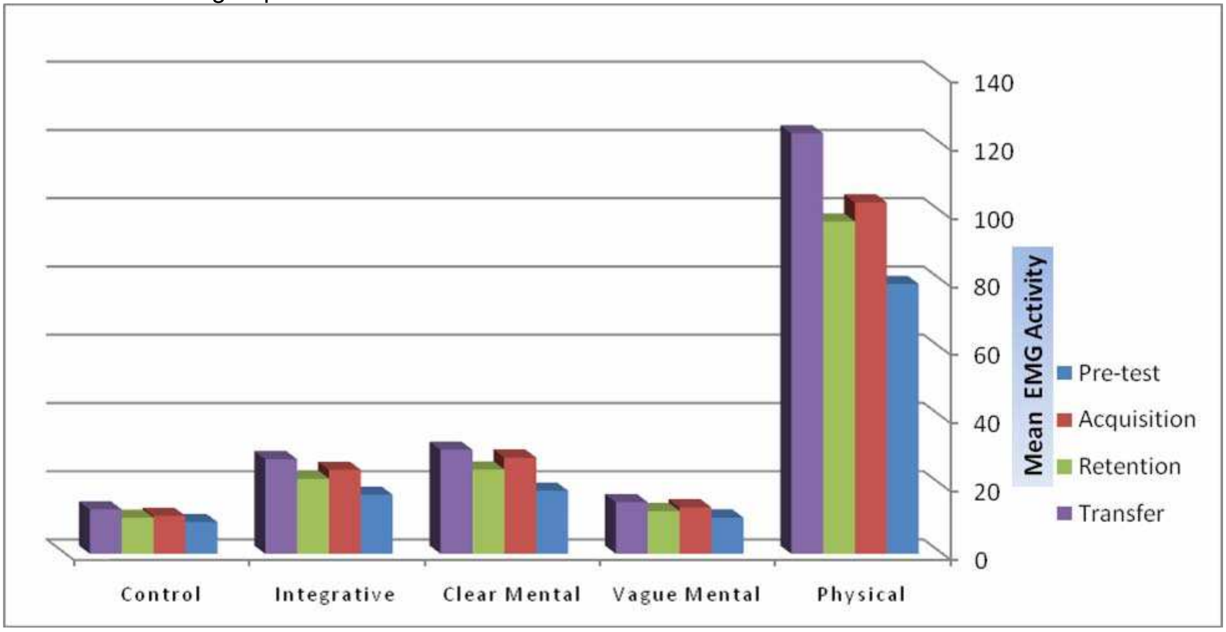

Fig. 1: A comparison of performance means of the study groups at pre-test, acquisition, retention and transfer stages.

Fig. 2 shows the progress of the study groups (10 kg) in consecutive weeks. Except for the control group, all the groups show a tangible drop in progress during exercising weeks till acquisition test and before retention test.

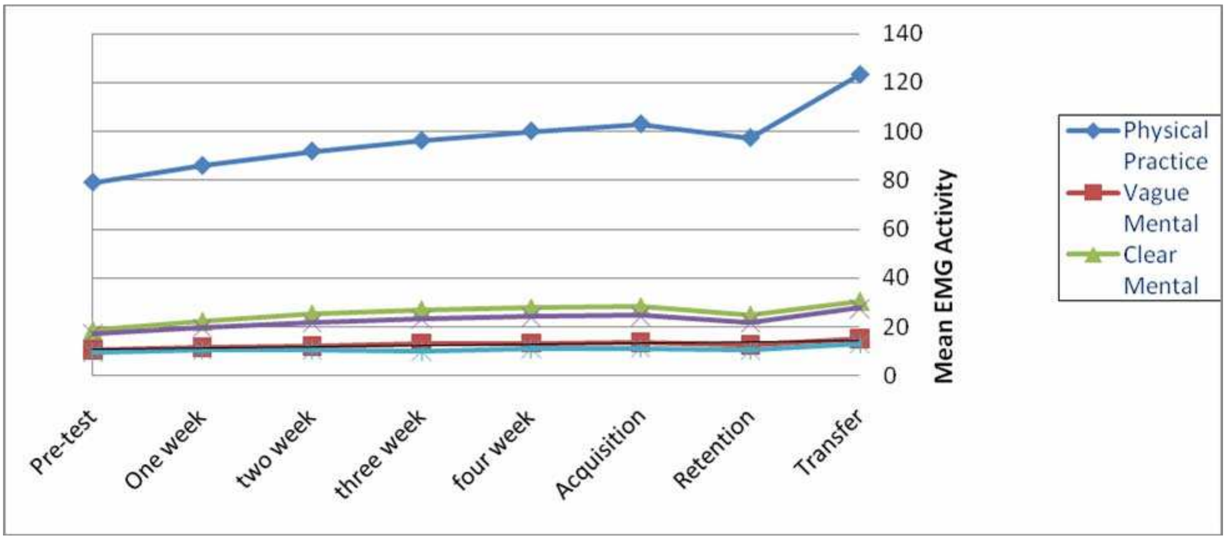

Fig. 6: Comparison of the progress of different groups during the practice period

Discussion :

As mentioned before, practice methods significantly affected the electromyography changes in the selected muscle at acquisition and transfer stages. The results of the present research conform to those found by Dickstein et al (2005) in the study on motivation of main muscles during mental imagery, McGinley et al (2003) and Bakker F. C. et al (1996). Other researchers such as Jackson (1930), Suinn (1967), Feltz (1983), Boorks (1986), Gandevia (1997), Jeannerod et al (1999), Sekulic et al (2006), Lafleur et al (2002), Hale et al (2003), Decety et al (1993) have shown similar patterns for the muscles used in mental and physical practice movements using electromyography techniques.

On the other hand, there are other researchers that have reported no muscular electromyographic activity during mental practice (Lotze M. et al, 1999; Zijdewind, 2003; Mulder et al, 2004; Decety et a, 1993, yue and Cole, 1992, Stephen, 1996, Lawrence , 2008). Decety et al (1996) found that electromyographic activity during imagery is not necessarily observable in all the muscles active in performance phase.

The results of the research show that practice methods used in this research don't have any significant effect on electromyographic changes in the Flexor Digitorum Superficialis muscle at retention state. The results of the present research confirm those of Mulder et al (2004), Jackson et al (2004).

Unlike the findings of the present research showing that mental practice has no significant effect on motor skill learning, some researchers such as Gabriele, Hall and Lee (1989), Sanders et al (2004) and weinberg (2003) have reported that mental practice, similar to physical practice, results in motor learning. Yaguez et al (1998), Cumming and Hall (2002), Hall (2002), Hall et al (2003), Dijkerman et al (2004), Sanders et al (2004) and Jackson et al (2004) have shown in separate studies that mental practice develops motor learning.

With regard to the findings of the present research and other similar researchers, it can be concluded that mental practice improves motor tasks according to electromyographic results. Inefficacy of mental practice in retention stage can be attributed to type of motor task. It seems that increase of electromyographic changes of the selected skeletal muscle due to mental practice is because of utilization of the motor units.

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TIBIOFEMORAL AND PATELLOFEMORAL JOINT FORCES DURING SQUATTING AT VARYING LOADS AND DEPTHS

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INTRODUCTION

Squatting is a resistance method widely used in athletic training, either in lower limb strength training for competitive sports (American football, rugby)(3), injury prevention (5), or during competition (power lifting, weightlifting) (1,6). Squatting is thought to strengthen muscular and ligamentous tissue around the knee (3), improve muscular strength (1,3), reduce the risk of injury (5) and increase performance (1,3). Despite the popularity of the exercise, the literature is equivocal about the forces experienced by the knee during squatting. This is particularly important given the current debate concerning the safety of the exercise, and the conflicting evidence within the literature as to the relative safety of the exercise in both squatting athletes and in occupational settings.

The appropriate depth when performing a squat is an emotive topic. In probably the most comprehensive review of the literature, Escamilla (5) suggested that squatting to a position with the thighs parallel to the floor was sufficient, and has the additional benefit of reducing the potential for injury to the menisci and cruciate and collateral ligaments. This recommendation contradicts the practice of many strength and conditioning professionals who advocate deeper squat patterns. It is therefore clear that further work is needed to quantify the force milieu within the knee at different depths. Equally, the effect of external load on internal knee forces is largely unknown.

There are broadly two approaches to the in vivo quantification of forces in the knee. Direct measurement techniques would be the preferred approach, but are currently problematic due to the technological challenges (4,12). For instance, the state of the art in direct in vivo measurement of TFJ is represented by the instrumented prosthesis of D'Lima and colleagues (4). However, the nature of prosthetic technologies implanted in patient populations during total knee arthroplasty has meant that the population studied with this technique has a reduced relevance to athletes and the high forces that go through the knee during sporting activities. Equally the production of a force transducer which is sufficiently small to be placed in the patellofemoral joint has not yet been achieved (8).

The alternative to the direct measurement of in vivo knee forces is their calculation using mathematical modelling techniques based upon less invasive measurements (9,10,11). A large number of studies have sought to quantify the loading of the knee during the squat using these techniques. These studies have suggested a wide range of possible joint forces. For example, for body weight squatting the TFJ and PFJ values are in the ranges of 2.5-7.3 × BW and 2.5-7.6 × BW respectively (2). This wide range makes drawing definitive conclusions as to knee joint loading difficult.

The methodological limitations present in a large number of the musculoskeletal modeling studies of squatting provides one explanation for the large range of knee forces found in the literature. These limitations are a result of an attempt to simplify the computational demands presented by complex biomechanical analyses and include the reduction of model parameters (9,10,11). This reductive approach ranges from the use of 2D models to represent 3D motion to the wholesale disregard as to the effect of muscle forces in the creation of joint contact forces (10).

It is therefore clear that a definitive account as to the forces in the knee during squatting is yet to be established. The purpose of this study is therefore to report the forces in the knee during squatting to different depths and using varying loads using a well posed musculoskeletal model.

METHODS

This study will report the results of a pilot study exploring the forces in the knee during squatting. A previously described musculoskeletal model of the lower limb will be employed to transform motion capture data into a 3D description of the right lower limb consisting of four linked rigid segments. The model comprises both a segmental and a musculoskeletal description of the lower limb. The model is therefore used to parameterize the 3D equations of motion of the lower limb incorporating a consideration as to muscle, ligament and joint contact forces. The equations of motion define an indeterminate problem that is solved using the optimization toolbox of Matlab.

CONCLUSIONS

This study will seek to inform the practice of strength and conditioning coaches by providing a description as to the variation in knee joint loading during squatting to various depths and with differing external loads.

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Muscle function and joint moment contributions to between jumping and jerking

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INTRODUCTION

Biomechanical characterisation of sport movements is a central component in understanding the transferability of performance potential and importantly the transfer of training effects in response to general training means. Although substantial data has previously been presented on both vertical jumping [e.g. 4,9] and weightlifting [e.g. 5,8] movements no research to date has compared moments and muscle function in jumping and jerking directly. Further whilst 2-dimensional and traditional inverse dynamics approaches have been used in the past these methods typically do not incorporate 3-dimensional control requirements or biarticular muscle function within the modelling process. The aim of this study was to quantify the moments of the lower limb during vertical jumping and the weightlifting jerk using a model which provides moments secondary to the optimisation of muscle forces, including biarticular muscles, in 3-dimensions.

METHODS

Motion capture (Vicon MX System, Vicon Motion Systems Ltd, Oxford, UK) and force plate (Kistler Type 9286AA, Kistler Instrumente AG, Winterthur, Switzerland) data was recorded from 12 athletic male subjects (age 27.1 y ± 4.3; mass 83.7 kg ± 9.9; height 1.79 m ± 0.07; maximum vertical jump 0.38 m ± 0.05). A previously described [1,2,3] musculoskeletal model and optimisation approach was used to simultaneously calculate the peak muscle activations for 163 distinct muscle elements and joint moments of the lower limb during vertical jumping and push jerking (40 kg).

RESULTS

Mean peak muscle forces from a selection of mono and biarticular muscle will be presented highlighting variations in the recruitment of hip, knee and ankle musculature between jumping and jerking. Mean peak moments in the sagittal plane demonstrated higher knee extension moments during jerking (2.45 ± 0.44 vs 1.74 ± 0.24; $p<0.05$) and hip extension moments during jumping (2.23 ± 0.81 vs 1.11 ± 0.73; $p<0.05$). Moments at the hip ($r=0.81$, $p<0.05$) and knee ($r=0.67$, $p<0.05$) were significantly correlated between jumping and jerking, but only knee moments generated during jumping ($r=0.63$, $p<0.05$) were correlated to jump performance. The activation of mono-articular muscles followed a proximal to distal trend (data not presented) whilst for jumping the bi-articular muscles provided simultaneous negatives powers across proximal joints and positive powers across distal joints (Fig. 2).

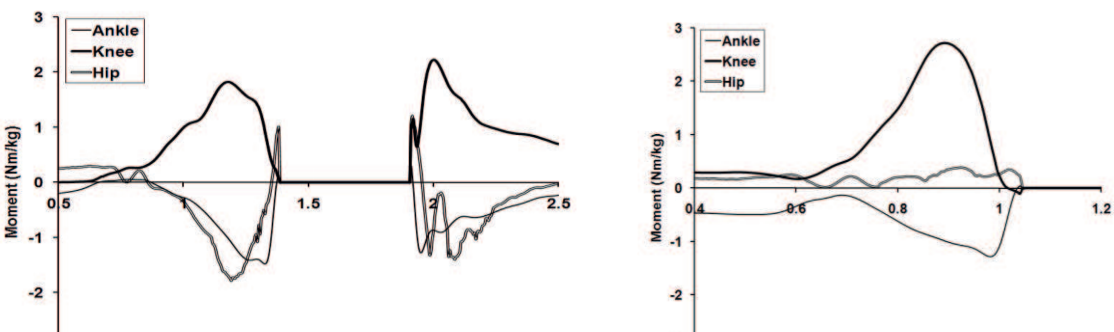

Fig.1 Typical joint moment profile in the sagittal plane for jumping and landing (L) and jerking (R).

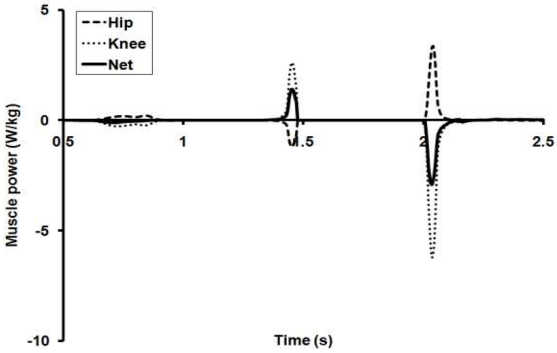

Fig. 2 An example of the muscle power profile of the rectus femoris (biarticular) muscle during vertical jumping.

DISCUSSION

The muscle forces to be presented represent values that are not constrained by previously calculated joint moments as is the case with traditional inverse dynamics approaches and so are higher for the biarticular muscles than would be found by traditional approaches with the same data (1). The biarticular muscle powers supported previous literature on jumping and the energy transfer role of bi-articular muscles [6,7].

In regard to sagittal plane moments the jerk presented higher knee moments and the jump presenting higher hip moments. Notably the athletes individually fell into jumping patterns that were either hip dominant (6 out of 12), knee dominant (2 out of 12) or more balanced (4 out of 12), although in all cases for the jerk knee moments were substantially higher than hip. This was not the case for jerking where all athletes demonstrated a knee based movement strategy, highlighting the jerk as potentially an effective strategy for overloading knee extensor moment generation in a lower limb triple extension task. However it is unclear how this might impact on jump performance considering the demand for high rates of moment generation (not assessed here, although effective propulsive time for the jerk was around 20% shorter than the jump) and the impact of increasing knee moment in isolation. The implications of the self selected jumping strategy (hip, knee or balanced) of the athlete is likely to be significant in this consideration.

Interestingly, during the optimisation of muscle forces, where trials were not solvable at normal muscle force bounds, higher upper bounds were utilised to allow a solution. In such cases it was generally noted that it was the smaller ‘stabilisers’ that required higher force capabilities to solve rather than the prime movers. This might offer insight as to the important function of stabilisers in allowing prime movers to express force effectively in the creation of sagittal plane moments and requires further investigation.

CONCLUSION

In relation to jumping, the jerk would appear to offer an effective strategy for overloading knee extensor moment capacity. However it is unclear the impact this would have on jumping performance due to the absence of meaningful hip involvement or apparent energy transfer strategies via the biarticular muscles.

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GENDER DIFFERENCES IN EXPLOSIVE STRENGTH IN TOP LEVEL ATHLETE

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INTRODUCTION

Gender difference in strength is an important topic in social and sport training.
Women are generally weaker than men in maximal strength and explosive strength, but very few data are available dealing with gender differences in top level sport, especially in explosive strength.
Explosive strength is the ability to develop maximal force in minimal time and is an important factor of performance in many sports. A practical and validated method to measure explosive strength is isometric testing with time to reach Maximal Voluntary Contraction (MVC) and different indexes has been proposed in the literature.
The aim of the present study was to determine a difference in explosive strength in a sample of male and female top level athletes practising 31 disciplines.

METHODS

A sample of 840 top level athletes (569 men age 25,8. 1,81 and 271 women) were measured with dinamographyc isometric maximal test and the left and the right limbs were separately registered for the leg and arm muscle.
For leg muscle a mobile seat was adapted for measuring at the standard position of 120°, for arm muscle an hand grip test it was applied at 90° elbow.
Explosive strength was measured as the time to reach 50% (T50) of MVC, it was also measured a Start Gradient (½ MVC/ T50) and a Relative Start Gradient (Start gradient/kg).
All data were elaborated in percentile form (25°.75°, 90°) and descriptive statistics parameters (average, standard deviation, median, minimum, maximum).
The comparison between male and female athletes was carried out with means differences, and with one way ANOVA.

DISCUSSION

Differences detected in Maximal strength (MS) between male and female athletes was about 25%, but in relative strength (Fmax/Body Weigth) no differences were detected. Explosive strength measured with T50 showed that in Leg strength women were weaker than men by 6% for legs and by 3% for arms strength while no differences was measured between left and right limbs. For the leg extensor relative start gradient a difference between men and women was 7% for the right side and 8% for the left side.

CONCLUSIONS

Top level male and female athletes show less differences in explosive strength than normal population, these results are new and underlines that training can adapt female athletes like male, without relevant differences as some former study showed in non athletes populations, more differences could be detected analysing and comparing results coming from different sport top level group.

THE INFLUENCE OF LIFESTYLE ON PHYSICAL FITNESS OF ELEMENTARY AND JUNIOR HIGH SCHOOL CHILDREN IN HOKKAIDO

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INTRODUCTION

According to a 2006 annual report on physical fitness of school children, it is documented that the level of physical fitness of school children in Hokkaido is lower than the national average. As a background that brings the decrease of physical fitness level, various changes of lifestyle of children in contemporary society are considered. It is meaningful that those changes of lifestyle and consciousness including the aspects of health and physical conditions, custom of life, environment of sport life, spirits in life and so on, are clarified to discuss the social system and management, and to improve educational skills at the level of society. The purpose of this study is to investigate some influencing factors of lifestyle on physical fitness of school children in Hokkaido and to show the strategy and the action plan of sport education.

METHOD

Participants (n=5558), aged 9 to 14 years, were fourth, sixth, and eighth grade students of 87 elementary schools and 46 junior high schools in Hokkaido district, Japan. The lifestyle of school children was assessed by means of a questionnaire. This questionnaire is composed of physical fitness (7 items), health and physical conditions (11 items), custom of life (12 items), environment for sport activities (5 items), self-esteem (10 items). All the participants were asked to respond on a “yes”-“no” scale to each item on the categories of physical fitness, health and physical conditions, custom of life, and environment for activities. Also, each item on self-esteem is measured on a Likert-type scale ranging from 1 (strongly disagree) to 4 (strongly agree). Total scores for each category were calculated on each scale. Multiple regression analysis was provided to extract influencing factors on physical fitness. In accordance with this factorial structure, the statistical treatment was given to analyze the relationship between each scale and each factor on the personal and situational conditions.

RESULT

The significant correlation was given between the total score of the physical fitness given by 7 items in the questionnaire and the score on the category of New National Fitness Test. Instead of New National Fitness Test, physical fitness score in this questionnaire was available and used to understand their fitness ability. As a result of Analysis of Variance among forth, sixth, and eighth grade, there were significant differences in male and female. In particular, the score of eight grade students in female was lowest significantly. The total scores of health and physical conditions, custom of life, willingness to exercise, environment for sport activity and self-esteem were calculated and the correlation matrix on these variables was discerned. All the correlation coefficients were significant. Multiple regression analysis shows that three major factors (intentionality to exercise and sport, environment for sport activity, and self-esteem) commonly contributed to physical fitness of each grade. Particularly, willingness to exercise was the most

important factor.
Considering health and physical conditions, the average score of higher grade students (especially in female) was relatively low. Focusing upon the life custom for the duration of study (home task or cram school etc.), videogame use, exercise and sport, sleeping patterns, and the style of meal, it is found that female students of eighth grade students seem to be poorer at sleeping, dieting, and exercise and sport. Compared with male students, the willingness of female students was much lower. In particular, the willingness of eight-year female students was shown to be lowest. The environment was one factor that enhanced their willingness to exercise and participate in sports. And this study revealed that the environment of sport life on the facilities, the sports programs, the clubs (companion), the coach…etc., induced higher willingness to sport activities. However, the school children was not satisfied with the sports program and/or sport coaching provided in their daily life, because of a short of sport program, and because of no skillful coach especially in the second grade of junior high-school. It is said that high self-esteem makes the enthusiastic and positive behavior with the satisfaction. As a result, the higher the school year is, the lower the self-esteem seems to be. One of the reasons why the self-esteem of eighth grade students in female is quite low is based upon the distortion of physique recognition.

DISCUSSION

This study is designed to evaluate the physical fitness of elementary and junior high school students in Hokkaido and examine the influencing factors such as health and physical condition, lifestyle, environmental condition, willingness, and self-esteem. It should be noted that physical fitness was influenced by personal, lifestyle, environment, and spiritual conditions such as gender, grade, health and physical condition, sport facilities, sport program, sport club, sport leader, sporting time, sleep patterns, food, and exercise, willingness, self-esteem and so on. The difference by gender would provide support for extending this line of research to promote health and sport participants of female students of junior high school [2]. It may also be suggestive that the children should be cultivated in the aspect of their spirit and educated to make sense of quality of life through their lifestyle. It is recognized in the previous reports [1, 3] that sport clubs at the level of school and community have an important function as parts of sport program services for children and that sport coaches and social support may form a basis in the consciousness and the intentionality of school children to involve in the exercise and sports activities. To improve their fitness level, the inter-woven relationship of these influencing factors were accepted as beneficial and meaningful for them, and that the health and physical education and the extracurricular activities at school can be an important role for it. School teachers should be aware of the importance of these factors in their involvement of exercise and sport. However, if more attention inclusively is paid to the matter of the decrease of physical fitness under these conditions, it will be necessary to incorporate positively with not only their family to cope with their custom of life but also the educational administration of sport to provide the sport environment in the community. It may also be worth considering that our university should recognize some information on influencing factors as guidelines for the development of the education skills of school, family, and regional society and make an important effort to offer educational services of sport and promote the physical fitness of children.

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UNSTABLE SUPPORT BASE COMPROMISES POWER OUTPUT IN CONCENTRIC PHASE OF RESISTANCE EXERCISE

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INTRODUCTION

Previous studies (e.g., Anderson and Behm, 2004; McBridge et al., 2006) showed lower peak isometric force during strength exercises performed under unstable than stable conditions, yet little is known about the muscular output during dynamic instability resistance exercises, namely those involving countermovement (CM). Therefore the aim of the study was to compare the power in acceleration and entire concentric phase of upper and lower body resistance exercises performed on stable and unstable surface, respectively.

METHODS

A group of 16 PE students (age 23.4 ± 1.9 y, height 181.5 ± 6.1 cm, and weight 75.1 ± 6.1 kg) performed randomly in different days 8 reps of a) barbell chest presses on either bench or Swiss ball, and b) barbell squats on either stable support or Bosu ball (all of them with 70 % of 1RM). A PC based system FiTRO Dyne Premium was used to monitor power in concentric phase of lifting.

RESULTS

Results showed significantly ($p < 0.05$) lower maximal and mean power (P_{max}, P_{mean}) in entire concentric phase when chest presses were performed on unstable (354.6 ± 12.8 W and 195.6 ± 18.0 W, respectively) than on stable surface (433.5 ± 12.5 W and 255.5 ± 10.3 W, respectively). Significantly ($p < 0.01$) lower was also power in acceleration phase (P_{accel}) of chest presses performed under unstable than stable conditions (215.3 ± 19.5 W and 327.4 ± 13.7 W, respectively). Similarly, these values were significantly lower during squats performed on unstable than on stable surface: P_{max} (390.4 ± 18.7 W and 565.8 ± 19.0 W, respectively, $p < 0.01$), P_{mean} (216.6 ± 23.2 W and 324.7 ± 9.2 W, respectively, $p < 0.05$), P_{accel} (271.1 ± 16.5 W and 380.1 ± 12.1 W, respectively, $p < 0.05$).

DISCUSSION

Lower power output during concentric phase of resistance exercises with CM performed on unstable surface may be ascribed to delayed amortization phase of stretch-shortening cycle (SSC). It is known, that activation of SSC during exercise with countermovement enhances the power output in concentric phase of lifting exercise. The mechanism of power production using SSC employs the energy storage capabilities of series of elastic component and the stimulation of stretch reflex to facilitate the muscle contraction over a minimal amount of time. If a concentric muscle action does not occur immediately following the eccentric one, the stored energy dissipates and is lost as heat and also the potentiating stretch reflex is fails to be activated. Instability resistance exercise may undermine all three phases of SSC, namely the amortization phase. Around this turning point, where the eccentric phase changes into the concentric one, maximal force is reached. Since at the same time subjects must stabilize themselves on unstable surface in order to accelerate the upward movement, this phase might take longer as compared to the exercise performed on stable base. As a consequence is lower velocity and power output in subsequent concentric phase.

CONCLUSION

Although the power is compromised during instability resistance exercises, the reduction rates are lower (~20 % for chest presses and 30 % for squats) as compared to previous findings on isometric exercises (~60 % and 45 %, respectively). Nevertheless, this fact has to be taken into account when instability resistance exercises are implemented into the training program, namely for sports requiring production of maximal force in short time.

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RESISTANCE TRAINING PATTERNS AMONG UNIVERSITY STUDENTS

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INTRODUCTION

Physical inactivity increases during the aging process with the most dramatic increase occurring in late adolescence and early adulthood. Many young adults on college campuses are not meeting current physical activity recommendations [1,2] and therefore may not be performing beneficial activities like resistance training. The purpose of this study was to examine the physical activity, specifically resistance training, patterns of college students.

METHODS

The study surveyed undergraduate physical education majors in a university in the Mid-western United States (N = 253). The majority of the respondents were male (170 or 67.2%) and between 18 and 24 years old (97.2%). Data were analyzed via PASW Statistics 18.0. Descriptive statistics and correlation were used to examine the relationship between five leisure and physical activities (i.e., typing/schoolwork on computer, web surfing/entertainment, weightlifting, video gaming, and aerobic exercise) and four independent factors (i.e., age, gender, year in school, and GPA). Violation of assumptions was checked prior to data analyses by examining both skewness and kurtosis values.

RESULTS

Skewness and kurtosis values ranged from |.022| to |1.794| and |.311| to |2.374|. All values were within the cut-off value of 2.58 at the .01 level [3], indicating multivariate normality among the data. The highest mean value indicated that the majority (76.7%, M = 2.73, SD = .52) of the respondents engaged in web surfing 6 to 7 days a week (television, Facebook, MySpace, etc.). Video gaming was the least frequently performed leisure activity (M = 1.43, SD = .67). The majority (66.8%) of the participants indicated that they engaged in video gaming zero to two days per week.

Descriptive Statistics

		M	*SD*
		Value	Value
Typing/Schoolwork on Computer	Frequency	1.9486	.61183
	Duration	2.4980	.55366
Web surfing/Entertainment	Frequency	2.7312	.51840
	Duration	2.6008	.59987
Weightlifting	Frequency	1.6759	.62812
(machine, free-weight, crossfit, etc.)	Duration	2.4348	.78723
Video gaming	Frequency	1.4325	.67350
(Xbox, Xbox360, PlayStation, etc.)	Duration	1.8498	.87807
Aerobic exercise	Frequency	1.8498	.69091
	Duration	2.3834	.67791

Correlational analyses revealed several significant findings. Significant positive correlation (r = .15) was found between the participants' age and the frequency of weightlifting, indicating older participants were more likely to engage in weightlifting. Significant positive correlation (r = .18) was found between the participants' gender and the frequency of weightlifting, indicating male participants were more likely to engage in weightlifting. Gender was also positively and significantly correlated with video gaming (r = .39), indicating male participants were more frequently engaging in video gaming. However, negative significant correlation (r = - .27) was found between gender and the frequency of aerobic exercise, indicating female participants were more likely to engage in this physical activity. The participants with a higher GPA were less likely to play video games as evidenced by the negative (r= - .14) correlation. In contrast, the participants with higher GPA were more likely to choose aerobic exercise (r = .20). Interestingly, the participants who spent more minutes on weightlifting engaged in both video gaming and aerobic exercises more frequently than who spent less (in minutes for both activities; r = .17 and .19, respectively).

Correlation Table

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	1												
2. Sex	.15*	1											
3. GPA	-.02	-.19**	1										
4. CP (F)	.07	-.05	-.01	1									
5. CP (D)	-.07	-.09	.05	.21**	1								
6. WS (F)	-.01	-.05	.04	.31**	.07	1							
7. WS (D)	-.12	-.04	-.08	.16*	.15*	.43**	1						
8. WL (F)	.15*	.18**	.10	-.12	.04	-.12	-.12*	1					
9. WL (D)	.05	.29**	.01	-.11	.04	-.12	-.08	.61**	1				
10. VG (F)	-.01	.39**	-.14*	-.06	-.03	.11	.10	.03	.10	1			
11. VG (D)	.05	.53**	-.12	-.04	.02	.09	.09	.16*	.17**	.67**	1		
12. AE (F)	.04	-.27**	.20**	.05	.11	.08	.08	.07	-.03	-.13*	-.12	1	
13. AE (D)	-.05	-.16**	.14*	.02	.13*	.01	.14*	.10	.19**	-.08	-.04	.48**	1

Note. CP = typing/schoolwork on computer, WS = web surfing/entertainment, WL = weightlifting, VG = video gaming, AE = aerobic exercise. F indicates frequency, and D indicates duration. Correlation is significant at the .05 level (*) and the .01 level (**).

DISCUSSION

There is a dearth of scholarly information explaining resistance training patterns in college students. Age and gender were found to be important variables predicting resistance training patterns as older males were more likely to be involved in resistance training and females were more likely to engage in aerobic training. Higher achieving students appear to have higher physical activity levels. Strategies need to be developed to attract a larger demographic group to resistance training in the collegiate setting as the there are many known lifelong benefits.

CONCLUSION

Future studies examining the physical activity patterns of college students should utilize larger samples to examine daily physical activity over longer periods of time to assess the efficacy of these findings.

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EFFECTS OF 6 MONTHS STRENGTH TRAINING ON TYPE–2 DIABETES PATIENTS

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INTRODUCTION

The incidence of diabetes mellitus, is a growing problem in the whole world. In Germany the prevalence in the sixties was about 0,6 percent of population. Today´s conservative estimates amount to about 10 percent (Hauner, 2008). Worldwide, diabetes currently affects 285 million patients, what represents about 6,4 percent of population. Estimation for the year 2030 reaches as many as 435 million (IDF, 2009). The disease is not anymore solely a disorder of elderly subjects, the youngest patient in Germany is only 5 years old and does live in Leipzig (Kurth, 2004). In Germany the prevalence of children overweight and obesity (between 3 – 17 years) is 15 percent (Korsten-Reck, 2008). As a consequence, the classification is based on pathological processes. Diabetes has been linked to the development of a variety of pathologies including heart disease, stroke, peripheral vascular disease, and neurological disorders. The cause of death in individuals with diabetes is not the disorder itself, but complications associated, most notably heart disease.
The major benefits of resistance training in individuals with diabetes are increased muscle mass and resting metabolic rate, improved insulin sensitivity and blood glucose control.
The aim of the study was to evaluate, which kind of strength training provides most beneficial effects for type-2 diabetes patients in terms of positive changes of haemoglobin.

METHODS

The participants included 90 type-2 diabetes patients randomized into 3 groups.
Group 1 performed sets with 10-12 reps, group 2 with 25-30 reps and the third control group did not do any exercise. The resistance training program consisted of 7 exercises activating larger muscle groups two times per week. The rate of perceived exertion after 4 weeks should have been "middle to a somewhat exhausting" (Buskies, 1996).
The haemoglobin-A1c were recorded before and after intervention of about 6 months. The age range of subjects was between 48 and 77 years without significant difference among the 3 groups. The test persons included sedentary males and females who have not exercised for the previous 2 years.

RESULTS

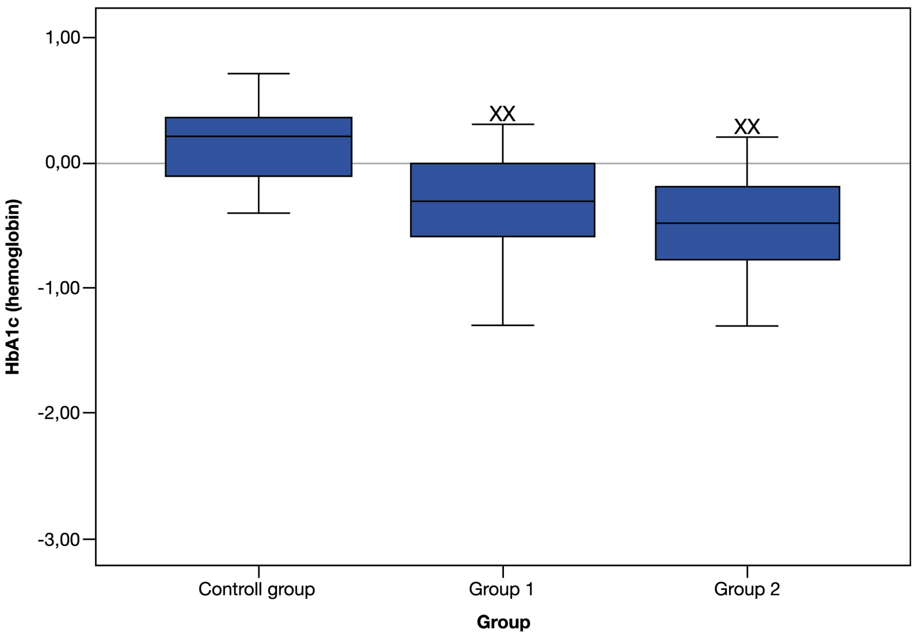

Abb.1 Effects of 6 months Strength Training on parameter haemoglobin-A1c during the study

The drop-out rate was 15,6percent. The haemoglobin improved in group 1 from initial 6,73% to the final 6,44%. Difference of 0.29 % was statistically-significant (p=0.001). Group 2 improved from 6.99% to 6,38%. Difference of 0.61% was also statistically-significant. The haemoglobin values of non-exercising control group 3 increased non significantly by 0.10%. Additionally, in group 1 and 2 six persons were able to reduce dosage of their medication. On the other hand in one patient from the group 3 the dosage had to be increased. The statistical analysis showed significant difference between groups 1 and 3 (p=0.001) and group 2 and 3 (p=0.001) respectively. However, there was no significant difference between group 1 and 2. In terms of descriptive statistic in group 2 the subjects had improved their haemoglobin-A1c by absolute 0.24 % more than in group 1.

DISCUSSION

The experimental group 1 and 2 have achieved during intervention period a significantly more pronounced improvement than the control group.
As expected the haemoglobin-A1c was reduced in the training groups 1 and 2. This is conform with the meta-analysis from Saam/Kann/Ivan (2006), even though the differences were not statistically significant. However, as building-up muscle mass and improving insulin sensitivity reflected by lower haemoglobin-A1c is a long term process, a longer intervention would be needed to achieve significant difference.

CONCLUSION

Both 6 month strength endurance training interventions (sets of 25 - 30 repetitions and 10 to 12 repetitions are efficient sport therapeutic modality for patients with type-2 diabetes.

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INTRINSIC MUSCLE STRENGTH IS INVERSELY RELATED TO PHYSIOLOGICAL CROSS-SECTIONAL AREA

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INTRODUCTION

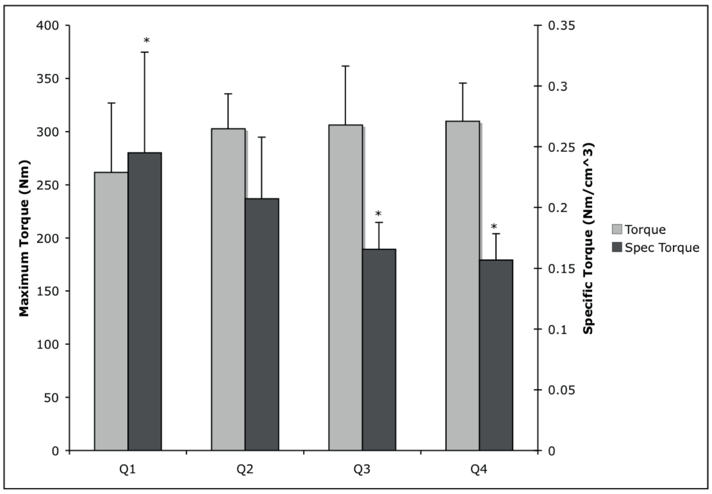
The maximum force generated by skeletal muscles is strongly affected by the physiological cross-sectional area (PCSA), representative of the sum of cross-sectional areas of all muscle fibers. Larger PCSA is often assumed to be reflected by proportionally greater muscle strength [5]. Yet, the linearity of this relationship has been questioned on several occasions, as the force-to-cross-sectional area (F:CSA) ratio, which is indicative of the muscle's intrinsic strength, may be influenced by several factors, including training status, sex, and age [4]. Data from longitudinal studies suggest that resistance training may induce relatively greater increases in muscle strength than in muscle size [2], whereas cohort studies indicate that the F:CSA ratio may be negatively correlated to muscle size [3]. Based on these inconsistent results, the present study aimed (1) to investigate the interrelationships between PCSA and maximum strength and (2) to elucidate possible reasons for differences in intrinsic strength.

METHODS

For these purposes, we examined the torque-angle relationships of the knee extensors by isokinetic dynamometry. Specific torque-angle relationships, indicative of intrinsic strength [1], were derived by normalizing the isometric torques to vastus lateralis (VL) muscle volume, which was regressed based on muscle thickness and thigh length [6]. VL muscle architecture was assessed by ultrasonography and PCSA was calculated as the ratio between VL muscle volume and fascicle length. VL fiber type distribution was estimated based on the isokinetic protocol proposed by Suter et al. [7]. Differences between subgroups formed by assignment to PCSA-quartiles (Q1-Q4) were tested with one-way ANOVAs and post-hoc independent sample t-tests were used for further analyses.

RESULTS

The results of this study show a positive, yet weak correlation between PCSA and maximum isometric torques (τ_{max}; $r = .335$; $p < 0.05$) and a moderate, negative correlation between PCSA and specific maximum isometric torques (specific τ_{max}; $r = -.659$; $p < 0.05$). Specific τ_{max} was found to be different between PCSA-quartiles ($F\ (3,37) = 6.414$; $p < 0.05$), with Q1 (smallest PCSA) achieving significantly greater specific torques than both Q3 and Q4. Furthermore, we observed a trend towards greater VL fascicle pennation angles with increasing PCSA ($r = .307$; $p = 0.051$). VL fiber type distribution was neither significantly correlated to PCSA nor different between PCSA-quartiles.



Tab.1 Maximum Torques and Specific Torques in PCSA-Quartiles

	τ_{max} (Nm)	spec τ_{max} (Nm)
Q1	261.5 ± 65.4	0.25 ± 0.08
Q2	302.8 ± 32.8	0.21 ± 0.05
Q3	306.3 ± 55.5	0.17 ± 0.02
Q4	309.7 ± 35.9	0.16 ± 0.02

Fig.1 Maximum Torques and Specific Torques in PCSA-Quartiles. Note: * denotes a significant difference at $p < 0.05$ (Q1 < (Q3 = Q4))

DISCUSSION

In line with theoretical considerations, we found the VL PCSA to be positively correlated to maximum isometric strength. However, the positive effects of greater PCSA were partly antagonized by decreasing specific torques. Inefficient myotendinous force transmission due to greater fascicle pennation and infiltration of non-contractile material seem to be the most likely candidates contributing to this loss of the muscle's intrinsic force. Estimates of the relative content of type II fibers militate against bias due to differential fiber distribution. Yet, several other factors, such as tendon moment arm length, tendon mechanical properties, neural activation patterns, and muscle architecture of the other heads of the quadriceps femoris muscle remained unaccounted for and may therefore have led to erroneous conclusions.

CONCLUSIONS

Increasing amount of contractile material, as represented by greater PCSA, benefits a muscle's absolute strength. The concomitant decrease in specific torques observed in our study, however, suggests that there may be a trade-off between additional contractile material and loss of intrinsic strength. These findings confirm the notion that an optimum rather than maximum degree of muscle hypertrophy is required to maximize muscle strength.

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THE EFFECTS OF 12 WEEKS OF RESISTANCE TRAINING UNDER STABLE AND UNSTABLE CONDITIONS ON NEUROMUSCULAR PERFORMANCE IN HANDBALL PLAYERS

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INTRODUCTION

Several authors have outlined the positive effects of balance training on neuromuscular performance in rehabilitation (1,2) and prevention of injuries (4,5).

On the other hand, there are only scarce studies investigating the influence of combined balance and resistance exercises on athletic performance (3). In addition, the authors found that a combined balance and strength training it is not more effective in enhancing motor capabilities, such as sprinting, bounce-drop jump (BDJ) or countermovement jump (CMJ) than a traditional strength training.

Therefore the aim of the study was to evaluate (a) the effect of resistance training on stable grounds, (b) the effect of resistance training on unstable ground and (c) the potential effect of the order of interventions on different athletic parameters.

METHODS

Based on a 1:1 randomization cross-matching design, the 24 players (age 16 ± 1.8 years, height 178.2 ± 3.6 cm, weight 71.3 ± 4.2 kg) were divided into two groups. Group 1 started 6 weeks with resistance exercises in form of chest presses and squats (twice a week, 3 sets of 8 reps with 70% 1RM) performed on unstable surface followed by 6 weeks of resistance exercises performed on stable surface. Group 2 started on stable surface also twice a week performing 3 sets of 8 reps with 70% of their 1RM of chest presses and squats for 6 weeks and then trained 6 weeks on unstable surface. Prior to, after 6 weeks, and after 12 weeks of training the parameters of balance (time standing on one leg – eyes open, eyes closed), strength (e.g RFD, Pmax, Pmean, Pacc), and endurance (e.g. average speed, passed meters, maximum pulse) were evaluated. Pre-post training changes were analyzed by two-factorial analysis of variance (training group; time of measurement).

RESULTS

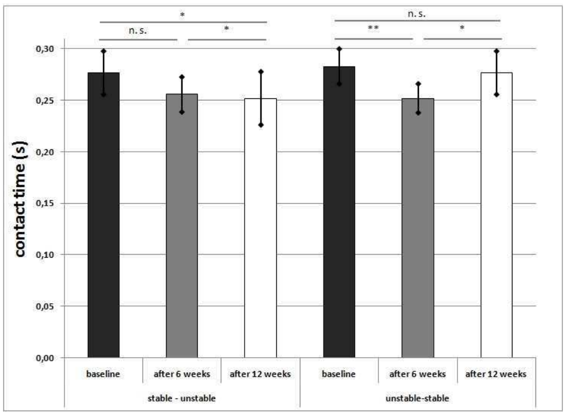

Figure 1: Ground contact time prior to, after 6 weeks and after 12 weeks of training for both groups (* p<0.05, ** p<0.01)

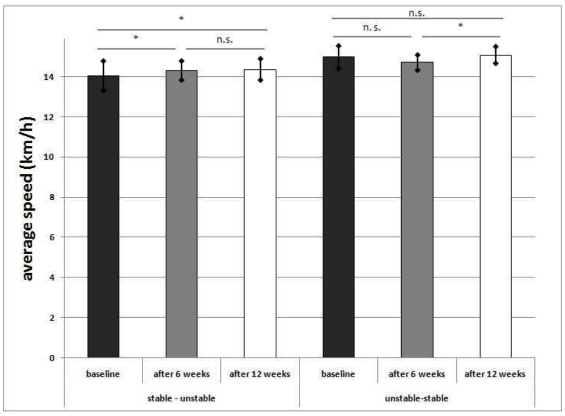

Figure 2: Endurance – average speed prior to, after 6 weeks and after 12 weeks of training for both groups (* p<0.05)

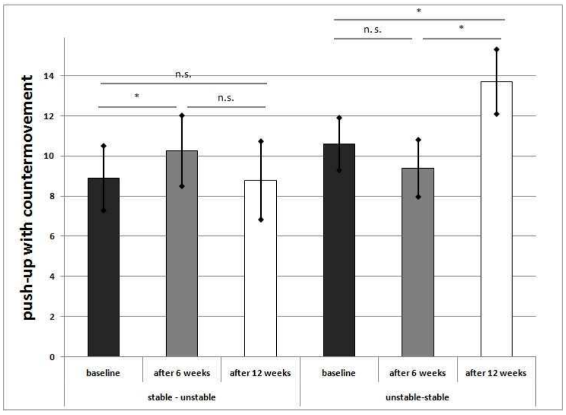

Figure 3: Push-up with countermovement prior to, after 6 weeks and after 12 weeks of training for both groups (* $p<0.05$)

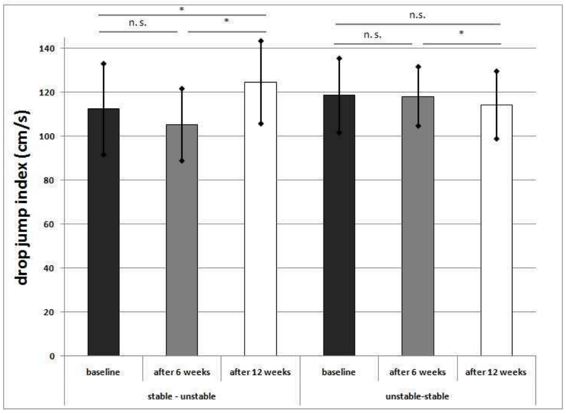

Figure 4: Drop jump index prior to, after 6 weeks and after 12 weeks of training for both groups (* $p<0.05$)

Results showed a significant improvement ($p < 0.05$) of ground contact time in drop-jump prior to and after 6 weeks of training (from 0.277±0.021 s to 0.256±0.017 s) in the stable – unstable group. A significant improvement ($p < 0.01$) was also found in the unstable – stable group (from 0.283±0.017 s to 0.252±0.014 s) prior to training to week 6. From week 6 to week 12 a significant longer ($p < 0.05$) ground contact was measured. Average speed significantly ($p < 0.05$) increased from prior to training (14.0±0.7 km/h to 14.3±0.5 km/h) to week 6 in the stable – unstable group. A significant improvement ($p < 0.05$) was also seen in the unstable – stable group (from week 6 - 14.7±0.4 km/h to week 12 - 15.1±0.4 km/h). The push-up with countermovement also improved significantly ($p < 0.05$) on in the stable – unstable group (baseline – 8.9±1.6 cm to week 6 – 10.2±1.8 cm) whereas in the unstable – stable group, a significant improvement ($p < 0.05$) from 9.4±1.4 cm at week 6 to 13.7±1.6 cm at week 12 was seen in the second part of the intervention. The drop jump index decreased significantly ($p < 0.05$) from week 6 to 12 in the stable – unstable group (from 118.1±13.4 cm/s to 114.1±15.4 cm/s). However, it improved significantly ($p < 0.05$) in the unstable - stable group from week 6 (105.3±16.5 cm/s) to week 12 (124.7±18.9 cm/s).

DISCUSSION

The findings indicate that a superiority of combined balance - strength training over traditional strength training was not present. Improvement was found only for ground contact time in drop-jump, average speed during running, push-up with countermovement and the drop jump index. Although non-significant trends of improvement for other parameters (1RM, drop-jump, RFD) were found after both training regimens, due to the rather small sample size, trends of increased 1RM and RFD values were found after both interventions. Additionally, no effect of the order of interventions was present for nearly all parameters.

CONCLUSION

Combined balance/resistance training is not more effective for improvement of 1RM, drop-jump or RFD than traditional strength training on stable ground for handball players who execute a daily handball training. Further research is needed on the possible effect of daily handball training on combined balance/strength training. None of the two regimens can be regarded superior for adolescents who also execute a daily handball training routine.

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First Author Index

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7th International Conference on Strength Training
Abstracts

Published by Slovak Olympic Committee
Printed in Slovakia by PEREX K+K, s.r.o.

Bratislava 2010

ISBN 978-80-89460-02-1