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ON STRENGTH TRAINING



Importance of Strength Training in Athletes and Clinical Populations: Mechanistic and Applied Perspectives

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Targeted forms of strength training can be employed to facilitate either high performance in sports, or exceptional recovery after illness or injury. Building a body that's capable of moving well, by optimising neural, muscular, and tendinous adaptations, may be a key element across a broad range of applied areas ranging from elite sports to clinical patients.

Influence of muscle fiber type composition on contractile Rate of Force Development (RFD) in vivo

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Differences in muscle fiber type composition across human skeletal muscles are paralleled by comparable differences in electrically evoked contractile Rate of Force Development (RFD), with muscles dominated by type II fibers expressing higher RFD (more steep Force-Time curves) than type I dominated muscles (Harridge et al. 1996). However, little is known about the relationship between muscle fiber type composition and RFD when examined in single heterogeneous muscles in vivo (Maffiulletti et al. 2016, Rodriguez-Rosell et al. 2018). The aim of the present study, therefore, was to examine the association between fiber type composition and isolated single-joint RFD for the human quadriceps muscle. Nine untrained male subjects without prior experience in systematic resistance training volunteered to participate in the study (age 24.2 ± 7.3 yr, \pm SD). Maximal isometric gravity-corrected knee extensor torque (MVC) and RFD were obtained (1000 Hz) at fixed 70° knee flexion (KinCom 500H, Chattecx Corp). Muscle biopsy samples (VL) were analyzed for type-specific cross-sectional area (CSA) and fiber type composition (Andersen & Aagaard 2000). Fiber CSA was 4535 ± 1271 , 5084 ± 1865 and 4502 ± 1970 μ m² for type I, IIA and IIX fibers (\pm SD), whereas fiber type area percentage was 48.5 ± 3.1 , 35.5 ± 2.5 and 15.9 ± 1.7 %. RFD correlated positively ($p < 0.01$) to type II fiber area percentage (0-30 ms: $r=0.79$; 0-50 ms: $r=0.83$; 0-100 ms: $r=0.81$ and 0-200 ms: $r=0.78$) (0 ms = onset of force). In conclusion, in vivo knee extensor RFD was strongly associated to type II myofiber content, which explained 63-69% and 61-66% of the variance (r^2) in RFD during the early (0-50 ms) and later (0-100/200 ms) phases of rising muscle force, respectively. In practical implications, resistance training aiming to preferentially increase type II myofiber CSA is expected to result in amplified gains in RFD.

The Effects of an 8-week Crossfit-based Training Program in Female Soccer Athletes by Player Position

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Background: As the popularity of youth soccer has grown in the United States, training programs that address the high metabolic and physical demands of the sport are essential, especially for female high school soccer players. The benefits of resistance training and high intensity interval training in young athletes has been well documented; however, the effects of a CrossFit-based strength and metabolic conditioning program in young female athletes has yet to be investigated. **Purpose:** This study examined the effects of an 8-week CrossFit-based training program in high school female soccer athletes. Body composition, speed, agility, strength, and power were compared. **Methods:** Subjects included 14 female high school soccer players, age (yrs) = 16.14 ± 1.02 , height (cm) = 162.92 ± 6.95 , weight(kg) = 58.7 ± 6.43 , who were grouped by player position (goalkeepers, forwards, midfielders, defenders). Body composition, performance testing, and strength testing were recorded before and after 8-weeks of a CrossFit-based training program performed 3 days per week. A one-way repeated measures ANOVA with a Bonferroni *post-hoc* test was used to determine significant differences between player groups. **Results:** Significant ($p < 0.05$) improvements were found in the 40-yd sprint, vertical jump, pro agility test, back squat, power clean, shoulder press, and bench press for all positions. Additionally, defenders showed significantly greater improvement in the power clean compared to midfielders ($p = 0.02$). In agility testing, midfielders demonstrated significantly less improvement compared to goalkeepers ($p = 0.02$), forwards ($p = 0.04$) and defenders ($p = 0.00$). Lastly, goalkeepers showed significantly greater improvement in vertical jump compared to midfielders ($p = 0.00$), forwards ($p = 0.00$) and defenders ($p = 0.02$). **Conclusion:** Overall, there were similar levels of improvement across all player positions in response to an 8-week CrossFit-based training program. This research supports the use of team training in female soccer players and may have practical application for individualized programming based on player position.

Should Non-responders To Resistance Training Increase Training Frequency?

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Considerable inter-individual variation occurs in response to resistance training (RT). However, it is not known if the modification of RT programming could influence training outcomes in those who appear not to be sensitive to the training stimulus. This study examined whether the responses of strength, hypertrophy and cardiometabolic health indicators to RT in non-responders are enhanced by increased training frequency.

Healthy older men and women (64-75 years) were randomized to RT (n=72) and non-training control (n=20) groups. For the RT group, a 3-month preparatory RT period was carried-out with two training sessions per week followed by a 6-month RT period when subjects were randomly assigned to the three groups performing one (EX-1, n=24), two (EX-2, n=23), or three (EX-3, n=25) RT sessions per week. Whole body RT was performed using 2–5 sets and 4–12 repetitions per exercise and 7–9 exercises per session. Pre- and post-study periods, maximal leg press strength, vastus lateralis muscle size (by ultrasound), and biomarkers of metabolic health (glucose control, blood pressure, blood lipids) were measured. Individual responsiveness to the initial 3-month RT period was defined by a response beyond technical error of measurement determined by the control group data.

In subjects defined as non-responders to the initial 3-month RT, the changes in maximal strength following 9-month RT were greater in EX-3 compared to EX-2 ($p < .01$) and EX-1 ($p < .05$). Such differences were not observed in non-responders in muscle size or in cardiometabolic health indicators.

The present findings indicate that non-responders to RT could benefit from increased training frequency especially regarding the adaptations in maximal strength. For other RT outcomes determined by this study, potential benefits of increased training frequency are not obvious. On the other hand, decreasing training frequency from twice-a-week to once-a-week did not prove to be detrimental to the non-responders either.

Resistance Training Induces Cardiometabolically Beneficial Alterations in Serum Metabolome Profile

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Arising evidence suggests that resistance training (RT) has the potential to induce beneficial modulation of serum metabolome profile. To this date, however, only immediate responses to resistance exercise has been investigated using high-throughput metabolomics whereas the effects of chronic RT on metabolome profile have not been studied in detail. Thus, the aim of the present study was to examine changes in metabolite profiles in response to RT and associated changes in body composition.

A total of 86 healthy men without previous systematic RT background were allocated in RT group (n=68, 33±5 yrs., BMI 28 ± 3 kg/m²) and non-RT control group (n=18, 31±5 yrs., BMI 27±3 kg/m²). Metabolomic responses to RT (full-body workouts, 50-95% of maximum load, 2 or 3 training sessions per week) were evaluated after 4 and 16 weeks of intervention using Nuclear magnetic resonance (NMR) -metabolome platform. Changes in body composition was determined by DXA.

Overall, RT intervention resulted in favorable alteration of body composition ($p < 0.05$) with increased lean mass (~2.8 %) and decreased android (~9.5 %) and total fat mass (~7.3 %). These changes in body composition were accompanied by cardio metabolically positive alteration of serum metabolome profile (FDR < 0.05) as indicated especially by the reductions in non-HDL cholesterol, apolipoprotein B and the increments in conjugated linoleic fatty acids levels. Increases in large HDL metabolites were positively associated with gained relative lean mass during the intervention period.

In conclusion, present RT resulted cardio metabolically beneficial alterations of the serum metabolome, specifically in cardio metabolically favorable levels of overall serum cholesterol profile and subsequent apolipoproteins. Furthermore, individuals with the poorest baseline body composition and biomarker profile benefitted the most from RT in terms of positive cardiometabolic health effects. Thus, RT can alter cardiometabolic risk factors in a beneficial way even in previously healthy young men.

Neuromuscular training and change of direction mechanics: performance & injury

Author: Jacqueline Alderson

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This presentation will outline the biomechanical mechanisms for ACL injury during change of direction tasks and examine the role of preparatory mechanics in creating a "safe postural zone" when attempting manoeuvres associated with increased injury risk. The critical role of biomechanically informed training will be discussed, including what might be missing in the training research thus far. The examination of current evidence will provide a framework for dispelling the notion that training to reduce injury risk needs to be separated from training for performance.

S&C Coach Education: Where's the coaching?

Author: Harvey Anderson

The demand for strength and conditioning coaches and with it S&C Coach courses are on the increase in the UK and worldwide (Dawson et al., 2013). It is recognised that S&C Coaches develop through a number of mechanisms, in a complex and non-linear fashion (De Lyon & Cushion, 2013); namely through formal, non-formal and informal mechanisms (Kuklick & Gearity, 2015; Gant & Dorgo, 2014)

It has been suggested that S&C coaches need to have sport specific knowledge and coaching pedagogical knowledge (Jeffreys, 2014), other authors argue that reflection skills are also critical (Hanratty & O'Connor, 2012), alongside relationship building (Tod, Bond & Lavalllee, 2012). Radcliffe, Comfort & Spence (2017) point to the need for high quality mentorship to allow novice S&C coaches to develop, and Anderson (2016) suggested that in addition to these, coaches also need inter-personal and inter-professional communication skills. Finally, Gearity (2009) concludes that S&C coaches need to know about: pedagogy, physiology, biomechanics, injury prevention & care, nutrition, speed, resistance training, sport psychology, sociology and management (p.77).

With such a large remit of potential topic areas to cover, the focus of this paper was on the formal learning programmes in the UK at Postgraduate level to see what is actually being delivered. A content analysis was carried out looking at modular descriptors of each of the 21 Postgraduate degrees advertised on their respective websites.

The result's demonstrated that there was a common (80%) structure for these programmes, with courses primarily being structured around sport science, a practical skills module, research methods and finally a dissertation. However, work placements were only available on 30% of the courses, and pedagogical/coaching modules only accounted for (20%) of all content. This paper discusses the implications for the development of S&C coaches in the UK, with a particular focus on pedagogy.

Comparison Between Six Weeks Velocity Based Training Versus One Repetition Maximum Percent Based Training Effects on Strength and Power

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Introduction: This study compared the effects of velocity-based training (VBT) and one repetition maximum (1RM) percent-based training (PBT) on changes in strength, power and sprint times when groups were matched for sets and repetitions but differed in training load prescription.

Methods: Twenty-four resistance-trained males performed six weeks of full depth free-weight back squats 3 times a week in a daily undulating format. PBT group lifted with relative loads varying from 59%–85%1RM, whereas the VBT group trained with loads that could be adjusted to achieve a target velocity from an Individualized load-velocity profile (LVP) that corresponded with 59%–85%1RM. Pre- and post-training assessments included 1RM, counter-movement jump with 30%1RM (CMJ), 20 m sprint, and 505 change of direction test (COD).

Results: VBT group had lower training loads ($p < 0.05$, $\sim 1.7\%1RM$), and maintained faster repetitions during training ($p < 0.05$, mean velocity = $0.76 \text{ m}\cdot\text{s}^{-1}$ vs $0.66 \text{ m}\cdot\text{s}^{-1}$) that were perceived with less difficulty ($p < 0.05$, rating of perceived exertion = 5.1 vs 6.0) compared to PBT group. VBT and PBT groups significantly improved their 1RM (VBT: 11.3% vs PBT: 12.5%), CMJ (VBT: 7.4% vs PBT: 6.0%), 20 m sprint (VBT: -1.9% vs PBT: -0.9%), and COD (VBT: -5.4% vs PBT: -3.6%) without significant differences between groups. However, *likely* favorable training effects were observed in 1RM for the PBT group, whilst VBT was *likely* favorable for the sprints, and *possibly* favorable for COD.

Conclusion: Both training methods are similarly effective but VBT may be preferred by some individuals since it is perceived with less difficulty, and accounts for day-to-day fluctuations in an individual's performance. This could be beneficial for athletes who partake in numerous training modalities where fluctuations in strength and velocity may be exacerbated.

Resistance training in the heat improves strength in elite rugby athletes

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Muscle adaptations are potentially enhanced through resistance training in elevated environmental temperatures (>30 °C) due to upregulated acute anabolic hormonal responses and enhanced power production (Cassadio et al., 2017). To investigate the longitudinal effects of training in the heat, 18 professional Rugby Union athletes (mean ± SD: age, 22.2 ± 3.5 y; body mass, 99.6 ± 11.5 kg; height, 187.6 ± 6.4 cm) performed a 3-week resistance training intervention (12 sessions) in which they were randomly allocated into one of two groups. The heat group (HEAT, n = 8) performed all lower-body resistance training sessions in an environmental chamber (35 °C and 37% relative humidity), while a control group (CON, n = 10) performed identical training under controlled temperate conditions (21 °C and 45% RH). Both groups performed their upper-body sessions in the temperate conditions. Pre- and post-training intervention tests included measures of 1-RM strength, countermovement jump velocity, aerobic endurance (20-40-60 m 'Bronco' shuttle), 10-m sprint speed, and body mass. *Small* effect sizes were found in favour of HEAT for the back squat ($d = 0.26$) and bench press strength ($d = 0.23$). All other measures demonstrated *trivial* or *unclear* effects. The CMJ velocity also increased to a greater extent in the HEAT condition ($d = 0.66$ vs 0.33 in CON). A significant group x time interaction for body mass, associated with a *trivial* effect size ($d = 0.19$, HEAT +1.5 kg; CON -0.8 kg) was observed. Lower-body resistance training in the heat led to enhanced improvements in lower and upper body strength compared to the identical training program performed in temperate conditions. These data have important implications given that no upper-body exercise was performed at elevated environmental temperatures and is suggestive of a priming or potentiating effect on upper-body strength of prior training in the heat.

Effect of drop jump training frequency on reactive strength in rugby athletes

Author: Daniel McMaster

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Background Jumping is a commonly used training modality to improve athletic performance and neuromuscular capabilities. The capacity to rapidly absorb eccentric forces and rapidly produce a concentric force within a stretch-shortening cycle (SSC) is referred to as reactive strength (RS)¹. The drop jump (DJ) assesses RS and has been used as a proxy for fast SSC (<250 ms)². The ability to utilise the fast SSC during running and jumping is an essential part of athletic preparation in rugby players³.

Methods 24 academy rugby athletes (97.3 ± 12.1 kg, relative 1RM back squat: 1.59 ± 0.24 kg/kg, 10 m sprint: 1.73 ± 0.09 s) performed an identical 6-week daily undulating periodized resistance training program but were randomly allocated to a high (3 sessions per week, [HF]) or low frequency (1 session per week, [LF]) DJ training group matched for RS.

Results Both groups improved RS (Effect Size [ES \pm 90% CL], LF: 0.55 ± 0.41 & HF: 0.70 ± 0.27 , both $p < 0.05$), and relative 1RM in the back squat (LF: 0.39 ± 0.12 & HF 0.36 ± 0.27 , both $p < 0.05$). There was a clear difference between the improvement in 5-0-5 agility times in favour of the HF group (ES: 0.28 ± 0.27 , $p < 0.08$). Only the HF group demonstrated a significant improvement in counter-movement jump performance (ES: 0.27 ± 0.21 , $p < 0.04$). No between group differences were observed in 10 m sprint times or relative 1RM in the back squat.

Discussion The higher frequency of DJ training improved agility and jumping ability in academy rugby athletes. To elicit positive changes in relevant functional measures requires a training commitment of at least three days per week. While RS and agility were related, there was no evidence of covariance over time.

Training for High Velocity Movement

Author: Tony Blazevich

The ability to move at high speeds is requisite for success in many sports and is also a goal of clinical rehabilitation programmes for individuals with compromised movement capacity. Numerous exercise training tools are available for the improvement of muscle function, including the ability to produce forces rapidly and, ultimately, to move at high speeds. However, selecting the most useful tools may be difficult because of our lack of understanding of (a) how humans produce high-speed movements, or high forces whilst moving quickly, from a biomechanical perspective, and (b) how training interventions impact the factors that then influence high-speed movement or force production during high-speed movements. The aim of this presentation is to describe the current state of knowledge in relation to how we perform high-speed movements, with emphasis placed on both neural and musculotendinous systems, and then to consider our current understanding of the impact of exercise training on these systems. An outcome of the presentation is to show how consideration of concepts of 'training specificity', specifically relating to the similarity between training loads and velocities and those of a chosen movement task (i.e. velocity specificity), can negatively impact training programme design and how a focus on understanding 'specificity of adaptations' to exercise training might allow for a broader and more successful training programme design. Finally, a working model will be developed for the use of exercise training in the development of high-speed movement performance.

Physical characteristics of Danish National Team Handball (TH) players 1990-2016: Possible implications on position specific strength and conditioning (S&C) training

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Many studies have documented differences in on-court position specific work demands in TH and suggest, based on these differences, position specific S&C-training. However, clear differentiation in physiological performance characteristics between players on different positions has been difficult to show. One reason being the difficulty finding sufficient number of top international players to include in studies. This study examined the anthropometric and physiological performance characteristics in male and female Danish TH players (since 1990, winning 4 Olympic, 7 World, 11 European senior medals) and compared anthropometry and physiological performance characteristics between playing positions (back court, wing, and pivot). From a federal database containing data from 1990 to 2016 of more than 800 physiological tests of national A and national U (under 21 years) players, 175 males and 138 females were extracted and the following tests were used: Height, body mass, body mass index, percentage body fat, fat free mass (FFM), VO₂max (mlmin⁻¹kg⁻¹), Fitness Index (mlmin⁻¹kg^{-0.73}), counter movement jump (CMJ), CMJ plus ½ body weight, jump and reach (JR), sprint 0-5 m, sprint 0-30 m, isometric abdominal strength and lower back strength. General position specific differences for both male and female players were wings being lowest, lightest and having lowest FFM, pivots having higher body mass and FFM than back court players. Back court players and wings had higher JR than pivots and wings were faster on 30m than pivots. In conclusion, the primary differences between playing positions were anthropometric, while the physiological performance characteristics, in general, did not differ between playing positions, except for the pivot's lower JR and the wings faster 30m. Indicating that differences in work demands do not generally impact the players performance in the physiological capacity tests selected in this study. Thus, it is questioned if position specific S&C-training would be worthwhile in international top players.

Generalized Joint Hypermobility (GJH) Syndrome Does Not Affect the Rapid Torque Production

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Generalized joint hypermobility (GJH) is a rheumatologic, genetically transmitted syndrome. One of its characteristics is the laxity of connective tissue throughout the whole organism due to genetic alterations in elastic fibers. The alteration of the soft-tissue strength is accompanied by unstable joints and it is possible that it might also affect the maximal and the rapid torque development (RTD) and might also cause a muscle activation delay. Therefore, the aim of the present study was to compare the rapid force development, measured by knee extensors and flexors RTD, between individuals with GJH syndrome and individuals without joint hypermobile. Methods: 33 young individuals aged between 18-35 years old (10 male and 23 female) were evaluated (17 with GJH and 16 without GJH). The participants were tested with the Beighton scale to define whether they had or not the joint hypermobility syndrome. Each participant attended to two visits, one for familiarization and another one for data collection. Isometric knee extension at 60° and knee flexion at 30° (0° = full knee extension) were evaluated for the rate of torque development analysis at 0-50, 0-100 and 100-200 ms. Two 3-s attempts of each knee action were performed with one-minute rest between attempts. Were used for the RTD analysis only the curves with the highest peak torque of the knee extensors and flexors. Independent samples t-test was used to compare the RTD of the knee extensors and flexors between groups. Results and conclusion: No significant differences ($p > 0.05$) between groups were found for the RTD measured at 0-50, 0-100 and 100-200 ms for the knee flexors and extensors, despite the non-hypermobility group exhibit greater RTD values. The results of the present study suggest that the presence of GJH does not affect the rapid force production as measured with the RTD.

Short-term Composite Training Enhances Neuromuscular and Fast Stretch-shortening Cycle Performance in Hurling Players

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Plyometric exercises elicit post activation potentiation (PAP) leading to acute enhancement in jumping and sprinting. To date, no investigation has examined the short-term training adaptations to a plyometric-sprint PAP protocol. To describe this protocol, the authors devised the term *composite training* defined as the combination of a plyometric exercise with an explosive activity such as a sprint run performed as a combined repetition and session. Therefore, the purpose of this study was to investigate the short-term effects of composite training on neuromuscular (maximum strength, jumping and sprinting) and fast stretch-shortening cycle (bounce drop-jump (BDJ)) performance in hurling players. A randomized counterbalanced group design was employed with baseline-, pre- and post-test measures. Twenty-one college and club-level hurling players were divided into a composite (COMP group, n = 10) or a sprint training (SPRINT group, n = 11) group. Both groups trained twice per week for 7-weeks with the SPRINT group performing 6 repetitions of 20m sprints and the COMP group completing 6 repetitions (1-repetition = 3 drop-jumps with a 20 m sprint after 15 s recovery). Significant improvements were observed pre- to post-training in both groups for the following measures: absolute three repetition maximum (3RM) back squat strength (12.73-17.62%, P = 0.01), 5m (5.74-9.49%, P = 0.006-0.04), 10m (4.27-5.59%, P = 0.007-0.02), 20m (3.35-3.98%, P = 0.003-0.01). However, there were significant performance improvements pre- to post -training for only the COMP group for BDJ contact time (-7.25%; P = 0.05) and countermovement jump (CMJ) height (height: 7.43%, P = 0.006). Specificity of training has shown that combining BDJs with 20m sprints is a superior training approach for enhancing neuromuscular performance in a time efficient manner in hurling players. Furthermore, the inclusion of BDJs are an effective tool to enhance fast stretch-shortening cycle efficiency.

The Amount of Body Fat Negatively Affects Blood Pressure And Heart Hemodynamics in Young Obese Women

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INTRODUCTION: Modern technology brings convenience to our life, but greatly reduces opportunities for physical activities, which is a main cause of excessive accumulation of fat in of the body, leading to obesity. Cardiopulmonary endurance in obese individuals is much lower than that of non-obese counterparts, and obese people are prone to cardiac aortic stenosis affecting cardiac hemodynamic and blood pressure, reducing physical fitness further and threatening the health. It should be noted that the age that obesity is developed has become younger and younger. This study investigated the relationships between the body fat percentage (%BF), blood pressure and cardiovascular hemodynamic parameters in young obese women.

METHODS: Fifty-four young (20-24 y) obese ($\geq 28\%$ BF) women were recruited for this study. Resting heart rate (HR), systolic (SBP) and diastolic blood pressure (DBP), pulse pressure, and cardiac hemodynamic parameters (stroke volume: SV, stroke volume index: SVI, cardiac output: CO, cardiac index: CI, ventricular ejection time: VET, early diastolic filling rate: EDFR%, end diastolic volume: EDV, end systolic volume: ESV, ejection fraction: EF%) were assessed. These variables were analysed by Pearson product-moment correlation coefficient for the relationships with %BF.

RESULTS: The %BF ranged between 31.0% and 47.1% among the participants. The %BF had a positive correlation ($p < 0.05$) with resting HR ($r = 0.333$), pulse pressure ($r = 0.288$) and EDFR% ($r = 0.275$), and a negative correlation ($p < 0.05$) with SVI ($r = -0.384$). However, no significant ($p > 0.05$) correlations between %BF and SBP ($r = 0.266$), DBP ($r = -0.041$), MAP ($r = 0.085$), SV ($r = 0.003$), CO ($r = 0.240$), CI ($r = -0.038$), VET ($r = -0.040$), EDV ($r = 0.094$), ESV ($r = 0.141$), and EF% ($r = -0.129$) were observed.

CONCLUSION: These results showed that obesity increased negative effects on some of the blood pressure and cardiac hemodynamics parameters. Physical activities have to be increased, but endurance exercises do not appear to be suitable, thus eccentric resistance exercise training including eccentric cycling might be a good start.

Effect of Progressive Unilateral Eccentric Training on Muscle Strength and Damage of The Contralateral Elbow Flexors

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INTRODUCTION: Muscle damage of the elbow flexors (EF) induced by eccentric exercise is less following the second bout performed at 1-28 days after the first bout performed by not only the same arm but also the opposite arm (contralateral repeated bout effect: CL-RBE) [Chen et al. *Med Sci Sports Exerc* 2016]. This study tested the hypothesis that the CL-RBE would increase when EF underwent progressive unilateral eccentric training (PET).

METHODS: Non-resistance trained young men were placed to an experimental group (Exp) or a control (Con) group (n=9/group). Exp group performed PET once a week (5 sets of 6 contractions) over 5 weeks with the load increased from 10%, 30%, 50%, 80% and 100% of maximal voluntary isometric contraction (MVIC) strength, followed 1 week later by 5 sets of 6 maximal eccentric contractions (100%EC) of the opposite EF. Con group performed 100%EC with one arm, and repeated the 100%EC with the opposite arm 1 week later. MVIC, range of motion, upper arm circumference (CIR), plasma creatine kinase activity and muscle soreness were measured before to 3 days after each PET and before and for 5 days after 100%EC. Changes in these variables after 100%EC were compared between groups by a mixed-design two-way ANOVA.

RESULTS: Exp group showed increases in MVIC for the trained (23%) and untrained arms (5%) and increases in CIR (3%) for the trained arm after PET ($P < 0.05$). Changes in all variables after 100%EC were 5-78% smaller ($P < 0.05$) for Exp group when compared with the first 100%EC of Con group, but the changes of Exp group were 4-59% smaller ($P < 0.05$) than those after the second 100%EC of Con group.

CONCLUSION: These results supported the hypothesis that the CL-RBE would be greater after PET than a single bout of 100%EC, and showed that the CL-RBE was increased 10-34% by PET.

Effects Of 4-week In-season Flywheel Squat Training on Jump Performance in Collegiate Men's Volleyball Players

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Introduction: A recent study reported increases in squat (SJ) and countermovement jump (CMJ) performance in volleyball and basketball players following 24-week (once a week) inertial flywheel squat training (Gaul et al. JSCR 2016). However, it is not known whether a short-term (e.g. 4-week) inertial flywheel squat training could improve jump performance and muscle function of well-trained volleyball players. This study examined the effects of 4-week flywheel-based eccentric-overload training on jump performance and muscle function in collegiate men's volleyball players.

Methods: Fourteen collegiate men's volleyball players (19-23) were randomly assigned to high-resistance (HRT, 0.050-0.085 kg/m², n=6) or low-resistance training (LRT, 0.010-0.075 kg/m², n=8) group. Both groups performed inertial flywheel training (squat and lateral squat) three times a week for 4-week (3 sets of 8-20 repetitions in a session) with progressively increasing the load. CMJ height, relative peak force (RPF), relative peak power (RPP), contact time (CT), and modified reactive strength index (RSI_{mod}) during vertical countermovement jumps performed on a force plate were assessed before and at 4 days after the 4-week training.

Results: No significant difference in the total work generated over the 4-week training was evident between LRT (22213.1 ± 4561.2 W) and HRT (24101.7 ± 2035.6 W). CMJ height did not change significantly following the 4-week training for both LRT (56.1 ± 3.6 cm) and HRT (53.9 ± 2.9 cm). RPF increased (P<0.05) from 22.3 ± 1.6 N to 24.1 ± 2.3 N for LRT, but no such effect was observed for HRT. No significant changes ($p > 0.05$) in RPF, CT, and RSI_{mod} were found after the 4-week training for both groups.

Conclusions: These results showed that the 4-week of inertial flywheel training performed in the season was not effective for improving jump performance of the collegiate volleyball players.

Keyword: eccentric training, countermovement jump, resistance training, muscle function

Attenuation of Maximal Eccentric Contraction-induced Muscle Damage by Maximal Isometric Contractions of The Knee Extensors in Older Adults

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INTRODUCTION: Maximal voluntary isometric contractions (MVIC) attenuate muscle damage by maximal eccentric contractions (MaxEC) of the knee extensors (KE) in young men (Tseng et al. *Res Sports Med* 2016). However, it is not known whether this is also the case for the elderly individuals. The present study investigated whether MVIC at a long muscle length would attenuate the magnitude of muscle damage induced by MaxEC of the KE of older adults.

METHODS: Healthy older (60-76 y) men were assigned to a control (Con) or an experimental (Exp) group (n=13 per group). The Con group performed 6 sets of 10 MaxEC of the KE of the non-dominant leg, while the Exp group performed 6 sets of 10 MVIC of the KE at 90° knee flexion prior to 6 sets of 10 MaxEC that were performed 2 weeks later. Changes in maximal voluntary isokinetic concentric torque (MVC-CON), angle at peak torque, range of motion (ROM), upper thigh circumference, muscle soreness (SOR), plasma creatine kinase (CK) activity and myoglobin (Mb) concentration and B-mode ultrasound echo-intensity before and for 5 days after MaxEC were compared between groups by a mixed factor ANOVA.

RESULTS: Small but significant changes in MVC-CON (-14%), ROM (-3%), SOR (5 mm) and plasma CK activity (372 IU/L) were evident after MVIC ($P<0.05$). Changes in all variables after MaxEC were significantly smaller ($P<0.05$) for the Exp than the Con group. For example, peak SOR and CK values after MaxEC were 55% (7 mm) and 43% (1035 IU/L) smaller ($P<0.05$) for Exp than those of Con (19 mm, 1523 IU/L).

CONCLUSION: These results suggest that MVIC attenuated the magnitude of muscle damage induced by MaxEC for the elderly men. The magnitude of the protective effect appears to be similar between young men (Tseng et al. *Res Sports Med* 2016) and elderly men.

Neuromuscular Adaptations to Mixed Session and Traditional Periodization in Aging Adults: A Randomized Trial

Author: Bruno Monteiro de Moura

Co-authors: Ewertton de Souza Bezerra, Lucas Bet da Rosa Orssatto, Antnio Renato Pereira Moro, Fernando Diefenthaler

Background: Improvements of maximal and rapid force and muscle mass following resistance training can attenuate the deleterious effects of aging on neuromuscular function. These adaptations depend of training specificity. Maximal force improvements are optimized by greater intensities, hypertrophy by moderate, and rapid force by light to moderate (with fast concentric action). However, it is unclear if mixing sets with the characteristics abovementioned within the same training session (i.e. mixed session periodization - MSP) would allow concomitant and larger improvements of maximal and rapid force and hypertrophy, compared to traditional periodization (TP).

Aim: To compare the effects of MSP and TP on neuromuscular performance in aging adults.

Methods: 22 men and women (64.6 ± 5.2 years) were randomly assigned into MSP (n=11) or TP (n=11), for a 9 weeks (3x/week) resistance training. Both groups performed sets of maximal strength [3-5 repetition maximum (RM)], hypertrophy (10-12-RM), and power (4-6 reps) according to their periodization scheme. MSP performed one set of each type per exercise (all sessions). TP performed three equal sets with the same characteristics on each training phase (1-hypertrophy; 2-maximal strength; and 3-power). Tests were performed at baseline and after every three training weeks (Testing weeks: 0, 4, 8, and 12). Normalized leg press 5-RM by body mass [$5\text{-RM}_{\text{LP:BM}}$], knee extension isometric peak torque (PT_{KE}), knee extension rate of torque development at 0-50 and 0-200 ms (RTD_{0-50} and RTD_{0-200}), and thigh lean mass (DXA) were assessed. Two-way ANOVA repeated measures (Bonferroni) compared group-time effects ($p < 0.05$).

Results: Both MSP (28.8%) and TP (26.4%) similarly improved $5\text{-RM}_{\text{LP:BM}}$. Only MSP improved PT_{KE} (15%) and thigh lean mass (5%). No improvements were observed for RTD_{0-50} and RTD_{0-200} for both groups.

Conclusions: Both periodization protocols were effective to increase dynamic strength, however only MSP improved isometric peak torque and lean mass. None periodization models increased RTD.

Effect of muscle length on muscle stiffness changes in the rectus femoris after repeated bouts of knee extensor eccentric exercise

Author: Ryoichi Ema

Co-authors: Ryosuke Kawashima, Akihiro Kanda, Koya Ikeda, Kazunori Nosaka, Ryota Akagi

Introduction: The rectus femoris (RF) length is approximately 10% longer for supine than sitting position. The current study tested the hypothesis that increases in RF muscle stiffness after knee extensor eccentric exercise would be greater for supine than sitting position, and the supine position exercise would confer greater repeated bout effect than the sitting position exercise.

Methods: Twenty-eight young (21-24 y) men were placed into two groups ($n = 14/$ group), and completed two bouts of exercise consisting of 100 eccentric knee extension contractions separated by 4 weeks, with the same knee joint range of motion ($40\text{-}110^\circ$). One group performed the exercise in sitting position (short RF lengths) for the first bout and in supine position (long RF lengths) for the second bout (S-L group). The other group performed the exercise in supine position (long RF lengths) for both bouts (L-L group). The resting RF shear modulus at 30% proximal of the thigh length was measured before and every 24 h for 3 days after each exercise bout, and the changes over time were compared by a three-way (group \times bout \times time) analysis of variance.

Results: A group \times bout \times time interaction effect was significant ($F = 2.771, P = 0.047$). The S-L group showed no significant changes in the shear modulus after both bouts, but the shear modulus increased (23–41%) for 3 days only after the first bout of the L-L group.

Conclusion: These results suggest that RF muscle stiffness was increased by the eccentric exercise at long RF lengths only, which induced protective effect on the second exercise bout. It is interesting to note that no significant changes in RF muscle stiffness were evident after the eccentric exercise in the sitting position, but it conferred protective effect on the eccentric exercise in the supine position.

Youth Resistance Training: Survival of The Strongest

Author: Avery Faigenbaum

A compelling body of evidence highlights the potential health-, fitness- and performance-related benefits of resistance training for children and adolescents, yet secular trends in muscular fitness indicate that a growing number of youth are weaker than previous generations. A systematic approach to physical development grounded in resistance training is needed to better prepare boys and girls for the long-term demands of physical activity, sport training and life.

Injury Perspectives: Incorporating Strength Training Approaches into Implementable Injury Prevention Practices

Author: Caroline Finch

Co-authors:

In many sports, large-scale epidemiological studies have identified that lower limb muscle and joint injuries are the most common type of injury. In response to this, considerable attention in the sports science and sports medicine literature has focused on developing, and investigating the efficacy of, training-based interventions, primarily to prevent lower limb injuries. A number of recent systematic reviews and meta-analyses have demonstrated that neuromuscular exercise training programs could indeed be effective in preventing injuries. The recent systematic reviews have also shown that the level of adoption of exercise training programs by athletes/coaches has been only low to moderate in several football codes. It is now apparent that for real-world injury prevention gains, these strength training programs need to be readily implemented and adopted by both athletes and coaches. Understanding why evidence-based interventions are and are not implemented or adopted by athletes/coaches has been recognised as an international challenge for injury prevention researchers. Despite this, it is now well accepted that the success of all sports injury prevention programs depends upon their adoption, implementation and maintenance by the people who deliver sport, such as coaches, sports conditioning personnel, sports administrators and allied health professionals associated with teams. Drawing on the experiences of the National Guidance for Australian football Partnerships and Safety (NoGAPS) project, this talk will demonstrate how to identify the factors that influence the translation of research evidence into sports injury prevention practice, using community Australian Football as the example. This talk will present a generalizable intervention development process to guide future intervention development. The importance of understanding and measuring the process of program implementation and behaviour change, as well as intervention effectiveness, will be demonstrated as being crucial to the future development and delivery of exercise training programs that incorporate strength and conditioning principles.

Photo biomodulation therapy effects on resistance training volume and discomfort in trained subjects: a randomized, double-blind, placebo-controlled trial

Author: Cintia Freitas

Co-authors: Lucas Bet da Rosa Orssato, Mateus Rossato, Monique Vargas, Fernando Diefenthaler

The aim of the present study was to investigate the effects of photobiomodulation therapy (PBMT) on resistance training volume and discomfort in well-trained subjects. Fourteen subjects ($n=7$, 27.7 ± 6.0 y; 57.6 ± 5.0 kg; and $n=7$, 28.3 ± 5.7 y; 88.3 ± 11.4 kg) volunteered to the present study. In the first laboratory visit, 12-repetition maximum (12-RM) test was performed unilaterally for both right and left legs on the Standing Calf Raises machine. After 7 days, in the second visit, and after more 7 days, in the third visit, subjects were randomly submitted to a PBMT (360 J) or placebo (device turned off) treatment in the right or left gastrocnemius and soleus muscles with a randomized crossover design. Five minutes after the treatment, subjects began the resistance training session, performed unilaterally with 6 sets of repetitions to concentric failure (100% of 12-RM load, 2 min rest). All repetitions were controlled by metronome - 2 s for concentric and eccentric contractions. In addition, the rate of perceived exertion for discomfort (RPE-D) was asked after each set. Before and after the resistance training session, the maximum voluntary isometric contraction force was assessed with a handheld dynamometer. Two-way ANOVA with repeated measures (Bonferroni posts hoc) and Student T-test were performed when appropriate ($p < 0.05$). It was observed after the training session a similar force reduction of $10.0\pm 13.6\%$ for placebo and $7.7\pm 7.3\%$ for PBMT ($p=0.815$). In addition, no difference between PBMT and placebo was observed for repetitions fatigue index (53.4 ± 11.7 and 50.0 ± 11.6 ; $p=0.325$) and total repetitions volume (55.4 ± 10.9 and 54.8 ± 13.0 ; $p=0.764$), respectively. RPE-D presented large means for all sets representing a large discomfort during resistance training to concentric failure for both PBMT ($>7.3\pm 2.34$) and placebo ($>7.5\pm 2.5$). In conclusion, the PBMT was not effective to increase volume and reduce discomfort during resistance training on the Standing Calf Raises machine by well-trained subjects.

Strength and Power as Determinants of Performance in World Class MMA

Author: Duncan French

This presentation will discuss the role of strength and power development in world-class MMA fighters competing in the UFC. The complex physical and physiological demands of MMA present a unique challenge to athletes. The presentation will give insights into the strength training strategies adopted by this athlete population, as well as giving consideration to strength diagnostics, performance standards, and the physiological adaptations that underpin health, wellbeing, and performance optimization inside the octagon.

Correlation Between Functional Hamstrings: Quadriceps Ratio and Jumping Performance in Collegiate Men's Volleyball Players

Author: Szukai Fu

Co-authors: Chun-Liang Chen, Wei-Chin Tseng, Chia-Hsien Yu, Chang-Chi Lai, Ken Kazunori Nosaka

Introduction: It has been reported that eccentric hamstrings torque (Hecc) and Qcon ratio (functional strength ratio, FSR) is more important than Hcon/Qcon ratio (conventional strength ratio, CSR) for joint stabilization during eccentric actions and may influence short-distance sprinting speed (Jenkins et al. JSS 2013). It is possible that FSR is a predictor for jump performance, since FSR could better represent stretching-shortening cycle capacity. Thus, the present study tested the hypothesis that FSR would be associated with jumping performance in collegiate men's volleyball players more than CSR.

Methods: Fourteen collegiate men's volleyball players (19-23 y) performed countermovement jumps (CMJ), squat jumps (SJ) and drop jumps (DJ) on a force plate. Maximal isokinetic concentric and eccentric contraction torque of their dominant knee extensors and flexors were measured at 60, 180 and 300°/s using an isokinetic dynamometer and CSR and FSR were calculated. Correlations between the variables were analysed by a Pearson product-moment correlation coefficient.

Results: A positive correlation was observed between Hecc/Qcon at 60°/s and CMJ ($r=0.737$, $p<0.05$), but not with SJ ($r=-0.327$) and DJ ($r=-0.081$). No significant correlations were evident between Hcon/Qcon at 60°/s and CMJ ($r=0.189$), SJ ($r=-0.461$) and DJ ($r=-0.099$). No significant correlations were found between Hecc/Qcon (180, 300°/s) as well as Hcon/Qcon (180, 300°/s) and CMJ, SJ and DJ. However, a significant correlation ($p<0.05$) was evident between CMJ and Hecc at 60°/s ($r=0.800$) and 300°/s ($r=0.504$) as well as Hcon at 60°/s ($r=0.631$), SJ and Qecc at 300°/s ($r=-0.650$), and DJ and Hecc at 180°/s ($r=0.729$) and 300°/s ($r=0.748$).

Conclusions: These results showed that Hecc:Qcon ratio at the slow angular velocity and Hecc at the faster angular velocities were more associated with jump performance in volleyball players. It is suggested that eccentric strength of hamstrings is important to improve jump performance of volleyball players.

Repeated sit-to-stand exercise enhances muscle strength and reduces lower body muscular demands in physically frail elders

Author: [Eiji Fujita](#)

Co-authors: Yasuhide Yoshitake, Dennis R Taaffe, Hiroaki Kanehisa

Purpose: To examine the effect of a conditioning program consisting of repeated sit-to-stand exercise on knee extensor strength and muscular activities during body mass-based squat movement in physically frail elders.

Methods: Fourteen men and women aged 75 to 88 years who used the long-term care insurance system participated in the 12-week training program (48 reps/session, 3 sessions/week). Isometric knee extension torque (KET) during a maximum voluntary contraction (MVC) and electromyogram (EMG) activities of the rectus femoris and vastus lateralis muscles during the MVC and a body mass-based squat task were determined at baseline and following 4 weeks and 12 weeks training. KET was expressed relative to body mass (KET/BM). The EMG activities during the squat task were normalized to that during MVC and averaged (QF %EMGmax).

Results: KET/BM increased from 1.07 ± 0.28 Nm/kg at baseline to 1.26 ± 0.26 Nm/kg at week 4 and 1.31 ± 0.28 Nm/kg at week 12 ($P < 0.001$), and QF %EMGmax decreased from 67.2 ± 17.2 % to 43.5 ± 7.7 % at week 12 ($P = 0.016$). At each of the three measurement time points KET/BM was inversely correlated with QF %EMGmax ($r = -0.78 \sim -0.86$, $P \leq 0.001$), although there were no significant association between the change in the two variables.

Conclusion: For physically frail elders, a short-term conditioning program consisting of repeated sit-to-stand exercise is effective in increasing knee extensor strength and reducing the muscular effort required for lowering and raising the body.

Strength and Power Characteristics of Male and Female World Top 20 Squash Players

Author: Chris Gallagher

Co-authors:

Introduction: Squash is an immensely popular sport with over 20 million players participating regularly world-wide, yet minimal data is published describing the physical performance characteristics of elite players. Furthermore, changes in scoring and court specifications have led to a faster more explosive game, questioning the relevance of older research.

Methods: Reactive Strength Index (RSI) was calculated from a drop jump performed from a height of 30cm (Swift SpeedMat).

Results: Male players demonstrate lower body bilateral strength values, assessed by the back squat, of 1.7x bodyweight (BW). By comparison, female players demonstrate back squat strength of 1.6xBW.

Elite male squash players demonstrate single-leg strength of 1.4xBW assessed by the barbell lunge, with female players demonstrating single-leg strength equivalent to BW.

Squash players demonstrate Power Clean performance of 1.14xBW for males and 0.91xBW for females.

Peak Power achieved in the Squat Jump exercise at a load of BW+20kg was 6977 Watts (W) for the male player and 3166W for the female player.

Reactive strength index values of 165 and 227 for female and male players respectively were found.

Discussion: Male players demonstrate significantly greater absolute values in all measures of strength and power performance. Female players demonstrate comparable relative lower body strength to their male counterparts.

Practical Applications: This study provides data on strength and power characteristics of elite male and female players currently ranked in the world top 20. Understanding the demands of squash and having an awareness of actual physical performance standards achieved by elite players can provide players and coaches with greater and more relevant data with which to guide their strength and conditioning training.

Resistance Training at High Versus Low Intensity on Hypertrophy and Strength: A Twin Case Study

Author: Stephan Geisler

Co-authors: Simon Gavanda

Introduction: No previous study has investigated the effects of high [HI-RT] and low intensity resistance training [LI-RT] in identical twins. Therefore, the objective of this study was to compare the effects of HI-RT and LI-RT on measures of strength and hypertrophy.

Methods: Two male identical twins (age=24; height: 183=cm; strength training experience=5 years) participated in this study. Pre- and post-testing included anthropometric measures consisting of ultrasound muscle thickness at three sites (vastus lateralis [VL], rectus femoris [RF], triceps brachii [TB]), BIA (body mass [BM], fat mass [FM], fat-free mass [FFM], muscle mass [MM]), as well as circumference assessment of the upper arm [UA], chest [C] and thigh [T]. Strength testing at baseline and following the intervention included 1-RM back squat [BS] and bench press [BP]. Subjects were randomly assigned to either LI-RT (3 sets of 20 repetitions) or HI-RT (3 sets of 10) prior to the 13-week intervention period consisting of two upper- and two lower-body RT sessions with 6 to 7 exercises per week. Subjects were instructed to perform each set of every exercise until they achieved concentric muscle fatigue or failed to maintain proper exercise technique.

Results: HI-RT lead to greater gains in BS (30.0 kg vs. 7.5 kg), BP (20.0 kg vs. 2.5 kg), BM (7.10 kg vs. 2.60 kg), FFM (7.30 kg vs. 1.90 kg), MM (6.00 kg vs. 1.00 kg), VL (0.25 cm vs. 0.11 cm), UA (3.16 cm vs. 0.66 cm), and C (3.33 cm vs. 0.50 cm). HI-RT lead to a greater loss of FM (-0.2 kg vs. +0.7 kg). RF showed little change (HI-RT -0.12 cm, LI-RT 0.00 cm respectively), while T increased in both groups identically (1.50 cm).

Conclusion: HI- and LI-RT to muscle failure affect hypertrophy and strength. However, HI-RT was more effective for adaptations in strength and hypertrophy.

Strength & Power Training: Practical Application in Collision Sport with Consideration of Travel, Injury Prevention and Recovery

Author: Nicholas Gill

Strength and power development can be achieved in many ways and with varying degrees of success. The structure of any high-performance programme is often influenced by time constraints or other “fixed” effects such as competition schedule, travel, sport specific training and traditions. We must always consider the big picture when programming for strength and power development and be conscious that it is the expression of an athlete's ability in the battle that is the priority and not the number in the gym! Considerations for prescription will be presented and the application of basic principles in a fast changing, high pressure environment will be discussed.

Untangling Periodisation Controversies

Author: G. Gregory Haff

Periodisation is a well-established method for guiding the training practices of athletes and clinical populations. Recently, the basic constructs and theories that underpin periodisation has been questioned in the scientific literature. This talk is designed to untangle the recent questions being made about periodization starting with defining the construct and explaining the classic contextual foundation of periodization. From the current criticisms of periodization theory will be deconstructed and critically analyze the effectiveness of periodization and basic mechanistic theories that are used to explain the concept. Periodisation will then be differentiated from the concept of programming. This talk will end with a detailed discussion how periodidation theory can be used in modern times.

Concurrent Training (Where from and where to?)

Author: Keijo Häkkinen

Adaptation to concurrent (C) strength (S) and endurance (E) training (T) has been of scientific and practical interests for almost 40 years. Hickson (1980) reported that high-frequency/volume-CT led to interference with S-gains, not during the first 4 weeks of training, but thereafter these initial S-increases plateaued during continued-CT leading to decreased-S after 7-10 weeks of CT. Although physiological stimuli to the neuromuscular system due to S/E-training are divergent in nature, CT may not impair S-adaptations, voluntary/muscle activation or hypertrophy over short-term T-periods and/or when T-volume/frequency is low/reasonable. When CT-volume was diluted by a longer time-period using low-frequency-CT (Häkkinen et al/2003), CT even for 21 weeks resulted in continuous S-gains accompanied with muscle hypertrophy/maximal muscle activation. However, even this type low-frequency-CT led to interference with rapid muscle activation and explosive-S. Continuous and HIIT E-running/E-cycling will interfere with S and explosive-S gains during prolonged CT (Häkkinen et al/2003/, Wilson/2012, Sagab et al/2018).

S and E can be trained on different days (DD) or during the same session in two-different orders (O), S+E or E+S. CT may not have specific effects on biological adaptations during initial weeks of CT leaving TO up to personal preference (Schumann et al/2014). However, in the early phase of CT recovery from single T-sessions of E+STO may be prolonged, and caution should be paid when performing high-volume/-frequency CT. S-E order should be recommended for lower-body dynamic S-gains both in men and women (Eddens et al/2018, Murlasits et al/2018). Moreover, neural adaptations may be compromised and large individual variation in S-development occurs, when E+STO is utilized for too long periods (Eklund et al/2015). Individual variation occurs also in the S-E-performance-ratio over prolonged-CT despite CTO. DD-training may be suitable for optimizing body composition both in men and in women (Eklund et al/2016). CS+ETO in the evening led to larger gains in muscle-mass and S, while E+STO might be more beneficial for E-gains, however, CTO and time of day seem to influence adaptations only, when CT-period exceeds 12-weeks (Küusmaa et al/2016).

In E-athletes both maximal/explosive ST performed concurrently with ET increased strength/power and muscle activation and coincided with increases in aerobic performance including running economy (Taipale et al/2010, Denadai et al/2017). C explosive/strength T is beneficial for both male/female E-athletes (Taipale et al/2014). However, in E-athletes constant use of E+STO may not lead to increased strength/power (Schumann et al/2015). CSETO in E-athletes and in previously untrained may not interfere with E-performance development.

In general, use of various E-modes (cycling/running and HIIT/continuous) and S-modes

(strength/power/hypertrophic) in CT should related to the needs/goals of an individual athlete with regard to purposeful gains to be obtained in strength and/or power during a planned training period. More research needed on effects of different CT long-term periodization strategies and appropriate timing as well as on length of between-mode recovery during CT.

Neuromuscular and Hormonal Responses to Sauna Bathing and Exercise Followed by Sauna

Author: Arja Hkkinen

Co-authors: Joonas Rissanen, Jari Laukkanen, Keijo Hkkinen

Introduction: We investigated acute effects of sauna bathing alone (SA) or endurance (E+SA), strength (S+SA) and combined exercise (C+SA) loadings followed by sauna on neuromuscular performance and serum hormone concentrations.

Methods: Twenty-seven young men (age 32.7, \pm 6.9 years) volunteered and were measured before (Pre) and after the loading (Mid), immediately (Post) and 30 minutes after sauna (Post30min) and 24 hours after the Pre measurement (Post24h). Maximal isometric leg press (ILPF_{max}) and bench press (IBPF_{max}) forces, rate of force development (RFD) of ILPF, serum testosterone (TES), cortisol (COR) and growth hormone (GH) concentrations were measured.

Results: All exercise loadings followed by sauna led to significant decreases in ILPF_{max} and RFD. IBPF_{max} decreased in Post only in S+SA and C+SA and remained lowered in Post24h. Sauna alone decreased both ILPF_{max} and IBPF_{max} in Post and Post30min. GH increased in Mid and Post in all other loadings except for E+SA in Post. TES increased in the subjects measured in the afternoon in Mid in S+SA (30.7 %) and E+SA (30.1 %) and COR in E+SA (87.0 %) and C+SA (70.4 %), respectively. The increase in TES also occurred in S+SA in Post24h. The subjects measured in the Morning showed no significant increases in serum TES or COR.

Conclusions: Large acute decreases took place in the neuromuscular performance after all loadings but it returned to baseline at Post24h except after S+SA. The present "strenuous" sauna bath alone decreased neuromuscular performance for 30 minutes and induced fatigue for 24 h. Sauna bath alone and all loading types led to the increase in growth hormone concentration, while serum testosterone concentration increased only in the afternoon group. Sauna bath can be recommended for athletes and recreational people as a part of their training routine but not too close before a training session.

Maximising The Training Stimulus - What Is the Role of Fatigue, Recovery and Sleep?

Author: Shona Halson

Maximising the training stimulus involves both carefully planned training, but appropriate use of recovery techniques around these training sessions. Importantly, this may reduce the risk of both overtraining and injury/illness in athletes.

Periodization of recovery has become an important consideration for athletes and coaches and is currently one of the more controversial and divisive aspects of recovery theory and practice. While much of the available evidence suggests that recovery aids such as cold-water immersion (CWI) may hasten recovery of exercise performance following *acute* strenuous exercise, there are many unanswered questions when considering adaptation and *chronic* exposure to these methods.

Practical considerations such as timing, duration, phase of training/competition, environmental conditions and type of exercise, are important considerations for both polarized training models and recovery during varying training cycles. Periodization of both fatigue and recovery is important to maximize both adaptation to training and performance and avoiding the risk of overtraining and illness and injury.

Sleep is considered the best recovery strategy available to athletes, and interestingly, it is not considered appropriate to periodize sleep. Recent data on the amount of sleep athletes are obtaining, means to improve sleep and behavior change strategies will be discussed.

A Simple Novel System for The Assessment of Balance.

Author: Dusan Hamar

Co-authors: Lubica Bohmerova, Janka Luptakova, Peter Schickhofer

Various devices have been developed to be used for the assessment of balance. They are usually based on analyses of horizontal movement of center of gravity vertical projection on the platform (center of pressure – COP). The amount of its horizontal movement expressed as a distance covered in a test is used as a parameter of balance capabilities. To obtain an instant position of COP majority of today´s system uses the force platform equipped with highly sensitive force transducers. COP is then calculated from force distribution to the four or 3 corner of the platform. The main drawback of such systems is their relatively high cost prohibiting broader utilisation in clinical practice. The simple and cost-efficient system developed in our institution uses different approach. Instead of on a firm surface, test person is standing on an unstable platform supported in corners by 4 metal springs. Horizontal shifts of its center of gravity cause two axes inclinations, which registration enables calculation of COP instant position. Physical formulas applied take into the accounts coefficient of elasticity of springs used, side dimension of quadruple platform (lateral distance from center to center of the supporting spring) and body mass of subject. Intraclass correlation analyses of repeated measurements (30 second tests) carried out on 101 subjects with eyes open revealed that intraclass coefficient on the labile spring supported plate ($r=0.932$) was comparable the one obtained from repeated measurements on the standard stable platform ($r=0,920$). The same applies to measurements with the eyes closed, where also similar intraclass coefficient for spring supported and firm stable plate were obtained ($r=0.868$ and 0.887 respectively). Results indicate that novel labile spring supported posturographic system matches the reliability of classic stable system based on force platform and can be applied for the assessment of balance capabilities.

MULTIPLE MOTOR FITNESS PREDICTORS OF KARATE PUNCH FORCE, PUNCH SPEED AND PUNCH RESPONSE TIME IN FEMALE KARATE ATHLETES

Author: Ian Heazlewood

Co-authors: Hovik Keshishian

Karate punching is an integral component of karate such as punch force, punch speed and punch response time. Previous research indicated punch force, punch speed and punch response time can be predicted from power, balance and agility tests in males. Research aim was to predict punch force, punch speed and punch response time based on general motor and karate specific motor fitness factors. Participants were 31 young adult female karate athletes classified as elite, intermediate and novice by experience and belt rank. General motor ability tests were standing long jump, isometric grip strength, sit-reach flexibility, arm crank and dynamic balance. Karate specific tests were karate agility, karate flexibility, punch force, punch response time, punch speed 50cm and punch speed 100cm. Statistical analyses were descriptive statistics; correlations between reverse punch factors and general motor and karate specific variables; stepwise multiple linear regression to evaluate predictor variables for different punch factors; and factor analysis evaluated interrelationships between four punch performance variables. Punch force was significantly and positively correlated with general balance, karate flexibility, long jump and strength; whereas punch response time with balance and karate flexibility; punch speed 50cm with general flexibility, karate flexibility and balance; and punch speed 100cm with general balance and inversely related. Regressions indicated punch force was predicted by balance; punch response time by balance; punch speed 50cm by general flexibility and balance; and punch speed 100cm by balance. Punch response time, punch speed 50cm and punch speed 100cm loaded on one factor and punch force was loaded on a second factor. Regression analysis indicated the most predictive variable for punch performance was dynamic balance, which has relevance to pre-punch stance and punch delivery. Factor analysis indicated punch force is a different concept from punch response time and punch speed, suggesting different training types to enhance punch performance.

Is optimal load for maximal power output during hang power clean indeed sub-maximal?

Author: Seiichiro Takei

Co-authors: [Kuniaki Hirayama](#), Junichi Okada

From a mechanical point of view, 1 repetition maximum (1RM) should be the optimal load for maximal power output during hang power clean (HPC); however, it is contrary to the findings reported in previous studies. The purpose of the present study was to investigate the underlying factors that made sub-maximal loads optimum for maximal power output during HPC. Eight competitive Olympic-weightlifters performed HPCs at 40, 60, 70, 80, 90, 95, and 100% of their 1RM. According to the previous studies, the success criterion was set that the catching position was higher than parallel squat. The ground reaction force and bar kinematics were recorded by using force platform and high-speed camera, respectively. Knee angle at the catching position was also measured. Peak system (bar and body) power was maximized at 80%1RM (3975 ± 439 W). Peak force and force at peak power showed a tendency to increase towards heavier loads ($p = .000$), while peak system velocity and system velocity at peak power significantly decreased above 80%1RM ($p = .005, .011$, respectively). Significant decreases in peak bar velocity ($p = .000$) and bar displacement (from height at peak velocity to the highest position) ($p = .000$) were observed in heavier loads. Pearson's correlation coefficients showed a strong positive correlation ($r > .90$) between peak bar velocity and bar displacement in 7 subjects out of 8. Knee angle at catching position decreased below quarter squat position (110°) at the loads greater than 70%1RM. These results suggest that, with the success criterion set above parallel squat position, sub-maximal load has become the optimal load for maximal power output. When the success criterion is set exactly to quarter squat position, however, 1RM becomes the optimal load of HPC.

The Relationship Between Occlusal Force and Power Profile During Exercise

Author: Hiroshi Hoshino

The aim of the present paper was to investigate unconscious clenching during physical activity and to determine whether it is related to overall athletic performance. In particular, the relationship between the stomatognathic system and strength and speed power types was examined. The values at rest and during maximum power output were determined from a comprehensive set of experiments.

The relations of anaerobic power and occlusal force was tested using 14 alpine skiers (nationally ranked within the top 200). Anaerobic power and occlusal force were measured at the same time using a Power Max V II stationary bike and occlusal force (dental prescale system).

The maximal voluntary contraction (MVC) was measured in 14 male subjects for 3 s while at rest, prior to any exercise and subsequently during low- and high-intensity exercises, following division into two groups. Prescale® film yielded force results that were analyzed using an Occluzer FPD-707® system. The occlusal force was measured using a Dental Prescale® 50H Series R type (Fuji Film Corporation, Inc.).

Subjects were then classified as strength type or speed type depending on their power profiles. The range of anaerobic power for the subjects was from 14.28 watt/kg to 14.63 watt/kg which are within the expected range for alpine skiers. Strength type and speed type subjects showed very pronounced differences in their occlusal force tests; strength type subjects occlusal force decreased rapidly during the three stages of the Power Max test while the speed type subjects showed no significant decreases at all. There is significant difference of two group to occlusal force at power max test in three stage ($p < 0.05$). In conclusion, we found a significant relation between anaerobic power profile and occlusal force. Future studies will be done to generate more detailed occlusal force contact profiles to determine whether or not force values in specific areas of the mouth can be used to determine power type.

In conclusion, the use of occlusal force is a viable method for determining muscle power profiles.

Changes in Muscle Function and Delayed Onset Muscle Soreness Following A Single Versus Multiple Soccer Matches in Female Players

Author: Chung-Chan Hsieh

Co-authors: Tai-Ying Chou, Kuo-Wei Tseng, Wei-Chin Tseng, Kazunori Nosaka, Trevor C Chen

INTRODUCTION: Muscle damage indicated by increases in creatine kinase activity and delayed onset muscle soreness (DOMS) is induced by a soccer match. It should be noted that multiple matches are often played by the same players in a tournament with minimum recovery between days. No previous study has investigated muscle damage responses to multiple soccer matches. Thus, the present study tested the hypothesis that multiple soccer matches would accumulate muscle damage and induce greater changes in muscle damage markers than a single soccer match.

METHODS: Ten female soccer players (19-23 y) in Chinese Taipei team for the 2018 Asian University Football tournament, played four matches (90 min per match). The first three matches were played every two days, and the last match was played 3 weeks later. Changes in maximal voluntary isometric contraction torque (MVC) and DOMS of dominant knee extensors, and Wingate test, Boidex balance test and agility (T-test) before and for 6 days after a single match and the last match of the three were compared between the single and multiple match conditions by a two-way ANOVA.

RESULTS: Significant ($P < 0.05$) changes in all variables were evident after both single and multiple matches. DOMS returned to baseline at 3 days after a single match, but MVC and other variables returned to baseline at 5-6 days post-match. Changes in all variables (peak DOMS: 42 mm, MVC at 1-day post-match: -26%, Wingate: -8%, balance: +16%, T-test: +12%) after multiple matches were significantly greater and slower ($P < 0.05$) recovery compared to a single match (26 mm, -17%, -5%, +8%, +4%).

CONCLUSION: These results supported the hypothesis that greater and prolonged decreases in muscle function and DOMS were induced by multiple than a single match. Thus, effective interventions to prevent muscle damage and/or enhance recovery are necessary.

Effect of Far-infrared Ray Treatment on Recovery from Eccentric Exercise-induced Muscle Damage

Author: Sheng-Tsung Hsu

Co-authors: Yu-Chuan Liu, Chin-Mou Liu, Kazunori Nosaka, Trevor C. Chen

INTRODUCTION: Far-infrared ray (FIR) is an invisible, non-ionizing electromagnetic radiation with 3-1000 μm wavelengths, and its shorter wavelengths (e.g. 8-12 μm) have been postulated to produce beneficial biological effects, such as increasing blood flow and alleviating pain (Hsu et al. *Q Chin Phys Edu* 2016). It is possible that FIR affects eccentric exercise-induced muscle damage (EIMD), but no previous study has investigated this. This study examined the effects of a 30-min FIR treatment performed daily for 4 days after eccentric exercise on indirect markers of EIMD in comparison to a sham treatment.

METHODS: Eight sedentary men (20-23 y) performed two bouts of 30 eccentric contractions of the non-dominant elbow flexors (EF) with a load of 80% maximal voluntary isometric strength (MVC) separated by 35 days, and received the 30-min FIR (8-14 μm) or sham (red light) treatment on the EF at 1, 25, 49 and 73 hours after each exercise using a counterbalanced and randomized double-blind cross-over design. Changes in several EIMD markers were measured before, immediately after, 24, 48, 72- and 96-hours post-exercise, and were compared between the conditions by a two-way ANOVA.

RESULTS: Significant ($p < 0.05$) decreases in MVC and range of motion and increases in muscle soreness (SOR) and plasma creatine kinase (CK) activity were found after EC for both conditions. The recovery of MVC was faster ($p < 0.05$) for the FIR (e.g. -7% at 96 h post-exercise) than for the sham condition (-23%) and increases in SOR (peak: 40 mm) and CK (peak: 441 IU/L) for the FIR condition were smaller ($p < 0.05$) than those for the sham (53 mm, 1023 IU/L).

CONCLUSION: These results suggest that the FIR treatment was effective for enhancing recovery from EIMD and attenuating the development of muscle soreness and increases in plasma CK activity after exercise.

KEYWORDS: delayed onset muscle soreness, lengthening exercise, muscle function, phototherapy, therapeutics

Damage protective effect conferred by low-intensity eccentric exercise on nine different muscles

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Introduction: Low-intensity eccentric contractions with a load corresponding to 10% of maximal voluntary isometric contraction strength (10%EC) attenuate muscle damage in a subsequent bout of higher-intensity eccentric contractions performed within 2 weeks for the elbow flexors (EF), knee flexors (KF) and extensors (KE). However, it is not known whether this is also the case for other muscles targeted in resistance training. This study investigated whether the protective effect by 10%EC on high-intensity eccentric contractions (80%EC) was evident for nine different muscles that are often included in a resistance training.

Methods: Sedentary young men were placed to an experimental (Exp) or a control (Con) group (n=12/group). Exp group performed 5 sets of 10 eccentric contractions with a load corresponding to 10%EC at 2 days prior to 5 sets of 10 eccentric contractions with 80%EC for elbow extensors, pectoralis, plantar flexors, latissimus, abdominis and erector spinae in addition to EF, KF and KE, in a counterbalanced order among the participants in the same day. Con group performed 80%EC without 10%EC. Changes in MVC and muscle soreness (SOR) of each muscle, plasma creatine kinase (CK) activity and myoglobin (Mb) concentration before, immediately after, and 1-5 days after 80%EC were compared between groups by a mixed factor ANOVA.

Results: 10%EC did not change any of the dependent variables. MVC recovered faster (e.g., 6-31% greater MVC at 5 days post-exercise), and peak SOR was 36-54% lower for Exp than Con group for the nine muscles ($P < .05$). Increases in plasma CK activity and Mb concentration were smaller for Exp (e.g., peak CK: $2,763 \pm 3,459$ IU/L) than Con group ($120,360 \pm 50,158$ IU/L).

Conclusion: These results showed that 10%EC was effective for attenuating the magnitude of muscle damage after 80%EC for all muscles, but the protective effect magnitude differed among the muscles.

The effects of exercise modality on predicting 1RM from the load-velocity relationship

Author: Liam Hughes

Co-authors: Jeremiah Peiffer, Brendan Scott

The load-velocity relationship (LVR) can be useful for predicting maximal strength (1RM), though the validity of these predictions may depend on whether free-weight (FW) or machine-based exercises are assessed. This study compared the reliability and validity of velocity-based 1RM predictions between FW and Smith machine (SM) exercises.

Eight males with ≥ 2 years' resistance training experience attended six testing sessions. Participants completed three visits using one modality (FW or SM depending on randomisation), before replicating the same three visits using the alternative. The first visit with each modality comprised baseline 1RM testing for the squat and bench press. The two subsequent visits included development of individual LVR for each exercise using loads of 30-90% 1RM, prior to direct assessment of 1RM. Velocity was determined using a linear position transducer. Predicted 1RM was calculated as the load at the intersection of the LVR and the velocity of baseline 1RM. Reliability statistics (ICCs and CVs) were calculated for 1RM predictions for both exercises, and two-way ANOVA examined the difference between predicted and measured 1RM from visits 2-3 and 5-6.

Good reliability was observed for 1RM predictions in the FW (squat: ICC=0.96, CV=4.9%; bench press ICC=0.98, CV=3.1%), and SM (squat: ICC=0.97, CV=2.1%, bench press: ICC=0.99, CV=1.4%) exercises. Differences between measured and predicted 1RM were observed for the FW squat (9.4 ± 1.8 kg; $p \leq 0.001$) and FW bench press (5.8 ± 1.6 kg; $p = 0.028$), but not for the SM squat (2.5 ± 1.1 kg; $p = 0.057$) or SM bench press (3.7 ± 0.9 ; $p = 0.061$).

The LVR 1RM predictions appear reliable when using either FW or SM exercises. However, differences between predicted and measured 1RM for the FW exercises indicate that velocity-based 1RM predictions cannot replace actual 1RM assessment. These differences are likely a consequence of a more variable bar path during FW compared with SM exercises, which could influence barbell velocity during training.

Using load-velocity relationships to estimate maximal strength in the prone row and overhead press.

Author: Liam Hughes

Co-authors: Jeremiah Peiffer, Brendan Scott

Several studies have used the load-velocity relationship (LVR) to predict maximal strength (1RM) in the squat and bench press exercises. However, the accuracy of these predictions in other resistance exercises has received less attention. This study aimed to determine the reliability and validity of velocity-based 1RM predictions in the free-weight prone row and overhead press exercises.

Eight trained (≥ 2 years' experience) males attended the laboratory on three occasions, each separated by 4-7 days. Baseline 1RM testing was conducted in visit 1 for both exercises and used to prescribe the loads for the subsequent sessions. Visits 2 and 3 comprised the development of LVR using loads of 30-90% 1RM, prior to another direct assessment of 1RM. Repetition velocity was estimated using a linear position transducer. The LVR regression equations were solved for the velocity of baseline 1RM, to calculate predicted 1RM. To assess reliability, intraclass correlation coefficients (ICC) and coefficients of variation (CV) were calculated for the predicted scores from visits 2 and 3. Pearson's correlation was used to examine the relationship between predicted and measured 1RM. Two-way ANOVA was performed to determine differences between predicted and measured 1RM from visits 2-3.

The ICC and CV scores were 0.99 and 1.5% for prone row, and 0.89 and 5.5% for overhead press. Very high correlations between predicted and measured 1RM were observed for prone row ($r=0.98-0.99$, $p>0.001$) and overhead press ($r=0.93-0.98$, $p>0.001$). Mean difference between measured and predicted 1RM were $0.6\pm 0.7\text{kg}$ ($p=0.426$) for the prone row and $1.6\pm 0.9\text{kg}$ ($p=0.116$) for overhead press.

These results suggest that LVR based 1RM predictions may be both reliable and valid assessments of 1RM in the prone row and overhead press exercises. This may provide practitioners with an alternative to direct measurement, which is less physically demanding and could be used more frequently to quantify maximal strength.

Effects of Strength vs. Endurance Training and Their Combination on Physical Performance Characteristics in Female Horseback Riders

Author: Anne-Maarit Hyttinen

Co-authors: Keijo Hkkinen

A horseback rider can follow with her stabilized and coordinated body the motion and influence the speed, direction and activity of the horse.

The purpose of this study was to investigate effects of strength(S), endurance(E), and concurrent endurance and strength (ES) training on neuromuscular and cardiorespiratory characteristics using the 12-week volume-equated protocols in female horseback riders.

The training consisted of riding exercise 4-6x/week including S, E or ES training 3x/week (30-60min) using the progressive training model. E included both interval and long-lasting low-intensity endurance training (biking and running), S consisted of 10 exercises for maximal strength and muscle-endurance training. ES trained 1.5x/week for endurance and 1.5x/week strength. Subjects (N=46) were of national to international level female horseback riders assigned to groups of S(n=11), E(n=11), ES(n=13) and control (C)(n=10). Their mean age was 29.4 ± 8.9 yrs, height 168.0 ± 6.1 cm, weight 67.5 ± 10.0 kg and BMI 23.9 ± 3.5 . The measurements included maximal isometric bilateral leg press force (MVC_{LP}) and rapid force production (0-500ms), countermovement jump (CMJ), maximal oxygen uptake (VO_{2max}) and cycling-time.

Only group S showed a significant ($p < 0.05$) increase in MVC_{LP} force. No significant increases occurred in CMJ or rapid isometric force production in any of the groups. Cycling-time in the ergometer test increased significant in all experimental groups ($p < 0.05$) with a significant increase ($p < 0.05$) in VO_{2max} only in ES.

Group S from the female horseback riders showed the significant gain in maximal strength, while the combined E+S group did not, maybe due to its lower volume/frequency of strength training and/or interference effects. However, S and ES showed no significant gains in dynamic speed strength or rapid isometric force production, perhaps due to the relative low volume of explosive strength training. All three experimental groups increased cycling performance time but only ES increased maximal oxygen uptake significantly indicating positive effects of the combined E and S training protocol.

Changes in hang power clean force-time curve characteristics following training

Author: Lachlan James

Co-authors: Mark Connick, Vincent Kelly, G. Gregory Haff, Emma Beckman

This experiment explores changes in the force production characteristics of the hang power clean (HPC), performed at lighter and heavier loads, following weightlifting-style training. Eleven recreationally trained males undertook 5 weeks of training with the weightlifting derivatives and other ballistic tasks across a series of heavy >80%1RM and lighter loads. All participants were supervised and instructed on the HPC and other weightlifting actions prior to commencement. Testing occurred at baseline and posttest and consisted of the HPC performed at 45% and 70% of the baseline one repetition-maximum (RM) power clean. Simultaneous force-time data were collected via a force platform sampling at 2000 Hz during both testing occasions. Data were then normalised to lift duration by resampling the data to 500 frames. This enabled a point-by-point comparison of the posttest force-time curves to baseline. A paired t-test with an alpha level of $P \leq 0.05$ was used to determine the presence of a significant change after training. Within the 45% condition, a significant increase in force was demonstrated at 2.0% to 25.0% and 48.6% to 68.0% of normalised time. In the 70% load, significantly greater force was present at posttest at 49.0% to 52.0% of lift duration. This investigation revealed that the changes to the HPC force-time curve following training differed between heavy and lighter conditions. When the HPC was assessed under lighter loads, improvements occurred in both early- and late-stage force development. This is in contrast to the heavier assessment condition where changes were apparent in the later stages of the lift only.

Resistance exercise to failure or not in hypoxia and normoxia: Acute changes in weight lifting velocity

Author: [Andrew Jonson](#)

Co-authors: Brendan Scott, Olivier Girard, Thomas Walden

Resistance exercise in hypoxia compared to normoxia, whereby oxygen availability is compromised, likely causes greater perturbations in movement execution as fatigue develops. However, the extent to which lifting velocity is differently impacted by hypoxic *versus* normoxic exposure when resistance exercise is performed to failure or not is unknown. This study aimed to quantify acute changes in weight lifting velocity when performing failure and volume-matched non-failure resistance exercise in hypoxia *versus* normoxia.

Ten active male subjects completed 10RM testing for the shoulder press and bench press exercises before undertaking four separate trials in an environmental chamber. Two trials were completed in normobaric hypoxia (13% O₂), and two in normoxia (21% O₂), with condition order randomised. Session one for each environmental condition comprised 3 sets to failure (1×100%, 1×80% and 1×60% 10RM), while session two involved the same volume load but over 6 sets (2×100%, 2×80%, and 2×60% 10RM). Mean concentric velocity of repetitions was quantified using a linear position transducer, with repetitions categorised into three velocity bands relative to the individualised minimum and maximum velocity for each load; 'slow' (lower 33%), 'moderate' (middle 33%), and 'fast' (upper 33%).

There was a larger number of repetitions completed in 'slow' (hypoxic and normoxic trials compounded: 10.5 *vs.* 0.6) and 'moderate' (16.1 *vs.* 6.1, respectively) categories for failure *vs.* non-failure protocols (both $p < 0.001$), while training to failure had significantly fewer repetitions in 'fast' category (7.8 *vs.* 27.3, respectively; $p < 0.001$). Hypoxia had no significant effect on the movement velocity profile ($p = 0.223$).

In conclusion, resistance exercise to failure preferentially decreased lifting movements that are executed at high concentric velocity compared to volume equated non-failure that showed an opposite pattern. Additionally, hypoxic exposure had no negative effect on performance patterns, indicating hypoxic implementation during resistance exercise is not detrimental to the velocity of lifting movements.

Approaches for Assessing Mechanical Muscle Function in ACL Reconstructed Elite Athletes

Author: Matt Jordan

Anterior cruciate ligament (ACL) injuries occur frequently in field sports and winter slope sports. After ACL injury, surgical reconstruction (ACLR) is often performed to restore knee joint stability. However, ACL injury and comorbidities associated with ACLR lead to persistent neuromuscular deficits that impair muscle strength and power. These deficits may contribute to an increased risk for ACL reinjury. In order to safeguard ACLR athletes against ACL reinjury and to restore preinjury performance, it is important to monitor mechanical muscle function throughout the return to sport/return to performance transition. With a specific focus on factors that affect muscle strength and power, the aim of this presentation is to present considerations for evaluating mechanical muscle function in ACLR athletes. The implications of ACLR on lower body maximal muscle power, lower limb kinetic asymmetry assessed with dual force plate systems, knee extensor/flexor rate of force development (RFD), hamstring muscle architecture, the quadriceps/hamstring torque-joint angle relationship and the vertical jump load-velocity relationship will be discussed.

Relationship Between Power Output during Maximal Pedaling Test and Sprint Performance on Track among Sprinters

Author: Nobukazu Kasai

Co-authors: Mitsuo Otsuka, Kazushige Goto

Most of the previous studies have evaluated relationship between several kinds of anaerobic performance test (e.g., Wingate test, Maximal anaerobic running test) and running time on track among sprinters. However, the correlation between maximal pedaling performance using different resistance (heavy load or light load) and sprint performance on track has not been fully elucidated.

PURPOSE: The present study was to determine the relationship between power output during maximal pedaling tests using two different resistance and sprint performance on track among sprinters.

METHODS: Thirty-four male and female sprinters [twenty-six men, height; 176.1 ± 1.0 cm, body weight (BW); 66.1 ± 0.8 kg, BMI; 21.3 ± 0.2 kg/m², 100m personal best; 11.0 ± 0.1 s, eight women, height; 161.7 ± 1.6 cm, body weight; 54.3 ± 1.6 kg, BMI; 20.7 ± 0.5 kg/m², 100m personal best; 12.4 ± 0.2 s] participated. They performed two pedaling tests, consisting of 10-s maximal pedaling (1.5% of BW) and 30-s maximal pedaling (Wingate) (7.5% of BW) with 10-min rest periods between tests. Peak and mean power output and pedaling frequency were evaluated. Furthermore, the subjects performed 2 × 60-m maximal sprint run on track with a 10-min rest period between sprints. Running time was recorded using a photocell system.

RESULTS: There was a significant inverse correlation between power output during 10-s maximal pedaling (1.5% of BW) and 60-m running time ($r = -0.78$, $p < 0.01$). A significant inverse relationship was observed between power output during 30-s maximal pedaling (7.5% of BW) and 60-m running time ($r = -0.90$, $p < 0.01$).

CONCLUSION: The present study demonstrated that maximal pedaling performance using both heavy and light resistance can be used to evaluate the sprint performance on track among sprinters.

Effects of manual eccentric versus concentric resistance training on muscle and functional fitness of older adults

Author: Yoshihiro Katsura

Co-authors: Noriko Takeda, Taketaka Hara, Sho Takahashi, Kazunori Nosaka

Introduction: Some studies reported superior effects of eccentric to concentric resistance training on muscle strength and hypertrophy, but less is known about the effects of manual eccentric or concentric resistance exercises with body weight (e.g., eccentric: sitting to a chair: concentric: standing up from a chair). The present study tested the hypothesis that manual eccentric resistance training (ECC) would improve muscle function and functional physical fitness of older adults greater than manual concentric resistance training (CON).

Methods: Healthy elderly (65-84 y) men (n=7) and women (n=10) were placed into either ECC (n=9) or CON (n=8) group. Both groups performed eight exercises (chair squat, one leg squat, calf raise, knee close and open, push up, sit up, elbow flexion and extension) once a week for 11 weeks. Eccentric muscle contractions were emphasised, and the load for concentric phase was minimised by the investigator for ECC, but in CON, the load in eccentric phase was minimised. Maximal voluntary isometric contraction torque of the knee extensors (MVC), muscle thickness of quadriceps (MT), balance ability assessed by center of pressure movement, and several functional physical fitness tests were assessed before and after the training.

Results: Both groups showed increases ($P<0.05$) in MVC, MT, sit and reach, 30-s chair stand (CS) and 2-min step (2MS) from baseline to post-training, and timed up and go (TUG) and balance with eyes close were improved only for ECC group. The magnitude of improvement of MVC, MT, CS, 2MS, TUG and balance were greater ($P<0.05$) for ECC (6.4-51.0%) than CON (6.0-34.6%).

Conclusion: These results showed that ECC was more effective than CON to improve muscle thickness, lower limb strength, mobility and balance of older adults. This suggests the importance of emphasising eccentric contractions in resistance training of elderly individuals to improve their muscle and physical functions.

Muscle Strength Measures on Isokinetic Dynamometer Do Not Reflect the Increases in Muscle Strength After Eccentric Resistance Training of The Elbow Flexors and Extensors in Older Adults

Author: [Neda Kiani Mavi](#)

Co-authors: Wafina Rohadhia, Favil Singh, Kazunori Nosaka

Introduction: Maximal voluntary contraction (MVC) strength measured by an isokinetic dynamometer are considered to be a gold standard, but do not necessarily reflect changes in muscle strength after resistance training. The present study compared the magnitude of changes in upper limb muscle strength assessed by MVC (isometric, isokinetic-concentric) and one repetition maximal (1RM) after eccentric resistance training performed by older adults.

Method: Ten sedentary older (60-80 y) adults performed eccentric resistance training of the elbow flexors (EF) and elbow extensors (EE) twice a week for 8 weeks using weight machines. Each training session consisted of 2 or 3 sets of 10 eccentric contractions with load (concentric contractions without load) by progressively increasing the intensity from 10%-100% of their concentric 1RM. Participants were tested for concentric 1RM, isometric MVC torque of EF and EE at 90° of the elbow joint, and isokinetic-concentric MVC of both muscles measured using a Biodex dynamometer before and after the 8-week training.

Results: Concentric 1RM increased ($P < 0.05$) for EF ($87.7 \pm 39.4\%$, range: 37.2-156.3%) and EE ($94.1 \pm 87.9\%$, 15.4-300.0%) from the baseline to post-training. Compared to the 1RM, isokinetic MVC showed smaller ($P < 0.05$) increases for EF ($10.0 \pm 36.3\%$, 0-85.3%) and EE ($20.1 \pm 35.9\%$, 0-101.0%), and this was also the case for isometric-concentric MVC (EF: $20.8 \pm 40.8\%$, 0-92.2%, EE: $5.5 \pm 24.9\%$, 0-57.4%). No significant ($P > 0.05$) correlation was evident between the changes in 1RM and isometric MVC (EF: $r = -0.404$, EE: $r = 0.321$) as well as isokinetic-concentric MVC (EF: $r = -0.208$, EE: $r = -0.270$).

Conclusion: These results showed that MVC measures on isokinetic dynamometer underestimated the eccentric resistance training effects that were better reflected by the 1RM. This may be partially due to the specificity such as bilateral eccentric training was performed, but its effects were assessed by unilateral isometric and isokinetic-concentric MVC measures, or concentric 1RM.

Delayed Onset Muscle Soreness at One Day After One-leg Eccentric Cycling in Relation to Decreases in Muscle Function Immediately Post-exercise

Author: Tomoko Koeda

Co-authors: Georgios Mavropalias, Kazunori Nosaka

Introduction: Delayed onset muscle soreness (DOMS) is induced after performing unaccustomed eccentric exercise, but its magnitude is not necessarily associated with the decrease in muscle function immediately post-exercise for the elbow flexors (Nosaka et al. 2006). No previous study has investigated those associations in the knee extensors after eccentric cycling. This study investigated the relationship between muscle function decrease at immediately post-exercise and DOMS at 24 h after eccentric cycling.

Methods: Eight men and five women (18-47 y) performed 10 revolutions of 1-min (50 rpm) right-legged eccentric cycling at 80% of their concentric cycling peak torque with a 1-min rest between sets. Maximum knee extension and flexion torque at 70° (MVIC70°) and 20° (MVIC20°), and maximum isokinetic knee extension and flexion torque at 90°/s (MVCON) were measured before and immediately post exercise. Muscle soreness was assessed by a 100-mm visual analog scale (VAS) upon palpation and pressure pain threshold (PPT) for vastus lateralis (VL), rectus femoris (RF) and vastus medialis (VM) before and 24 h post-exercise.

Results: No significant changes in knee flexion torque were found, but MVIC70°, MVIC20° and MVCON of the knee extensors decreased $25.1 \pm 15.8\%$ (range: 6.5-54.1%), $30.3 \pm 18.0\%$ (3.6-62.4%) and $21.4 \pm 15.6\%$ (6.1-56.3%), respectively. At 24 h post-exercise, VAS ranged 0-100 mm for VL (52.8 ± 29.3 mm), RF (47.2 ± 31.6 mm) and VM (48.8 ± 33.5 mm), and PPT decreased 30.3 ± 18.0 (0-59) % for VL, 20.0 ± 25.9 (0-55) % for RF and 22.3 ± 22.2 (0-48) % for VM. Spearman's rank correlation coefficient showed a significant ($p < 0.05$) correlation between MVIC (20°, 70°) and VAS ($r = 0.60-0.83$) as well as PPT ($r = 0.60-0.81$) for all muscles, and MVCON and VAS for RF.

Conclusion: These results suggest that the greater the magnitude of strength loss immediately after eccentric cycling, the greater the DOMS one day later.

Effects of Combined Blood-flow Restricted Training and Heavy-load Resistance Training on Mechanical Muscle Function

Author: Sofie Krarup Hansen

Co-authors: Jonas Ratzler, Jakob L. Nielsen, Charlotte Suetta, [Thue Kvorning](#), Ulrik Frandsen, Per Aagaard

While heavy-load conventional resistance training (HRT) is known to induce increased skeletal muscle size, strength, and explosive force, this training modality also results in high levels of stress on tendons and joints. Low-load resistance training (LRT) is less stressful to joints and tendons and is used during de-loading or tapering periods, despite mechanical muscle function remains largely unaffected with this training regime. However, by restricting blood-flow during low-load resistance training (BFR-RT) marked gains in mechanical muscle function and muscle size have been demonstrated. Although BFR-RT seems like an appealing alternative to LRT and HRT, it is still assumed that HRT is needed to efficiently stimulate neuromuscular drive.

Thus, the purpose of this study was to investigate if a block-structured training program consisting of alternating BFR-RT and HRT would induce similar adaptations in mechanical muscle function and muscle mass as to those seen following HRT alone.

Eighteen active males and females (23 ± 1.2 yrs) were randomized into two groups completing 6 weeks of progressive HRT (CR, $n = 9$) or block-structured weekly alternating (50/50%) HRT and BFR-RT (OCR, $n = 9$), with CR and OCR matched for total training time. Muscle biopsies (VL) were obtained and tests of maximal isometric knee extensor strength (MVC), rate of force development (RFD) and anaerobic capacity (Wingate anaerobic 30-s test) were performed before and after the intervention.

Both protocols led to increased ($p < 0.05$) type II muscle fiber cross-sectional area (OCR: +16%, CR: +16%) and MVC (OCR: +12%, CR: +7%), whilst only CR led to increased ($p = 0.05$) type I muscle fiber cross-sectional (+12%). Average Wingate power increased ($p < 0.05$) similarly following OCR (+2.2%) and CR (+2.1%) whereas Wingate peak power increased ($p < 0.05$) following CR only (+4%). In addition, RFD_{100ms} increased ($p < 0.05$) following OCR (+12%).

In conclusion, conventional HRT appears periodically replaceable by BFR-RT without compromising training-induced gains in muscle mass, strength and power. Practically, BFR-RT may be used periodically to unload tendons and joints, while maintaining mechanical muscle function.

Comparison Between Eccentric and Concentric Resistance Training Effects on Muscle Strength, Physical Function and Body Composition in Adults with Type 2 Diabetes

Author: [Christine Kudiarasu](#)

Co-authors: Favil Singh, Tomoko Koeda, Kazunori Nosaka

INTRODUCTION: The benefits of resistance training for people with Type 2 diabetes (T2D) is well documented; however, the effects of different muscle contraction types (e.g. eccentric, concentric) on physiological outcomes for this population are still unclear. This study investigated the effects of eccentric (ECC) versus concentric (CON) resistance training of eight upper and lower body exercises on muscle strength, physical function and body composition in adults with T2D.

METHODS: Twelve adults with T2D (64.8 ± 9.0 y; 30.3 ± 4.1 kg/m²) were randomly assigned to either an ECC (n=6) or CON (n=6) group. Participants performed 2-3 sets of 10 eccentric (5-s) or concentric (2-s) contractions, twice a week for 12 weeks. Training intensity gradually increased from 10 to 100% of 1-repetition maximum concentric strength (1-RM) for ECC and 50 to 100% for CON. Muscle strength (1-RM), body composition (dual-energy x-ray absorptiometry), and physical function tests consisting of 6-min walk (6MWT), chair rise (CR), timed-up-and-go (TUG), and balance were measured pre- and post- training, and the changes were compared between groups.

RESULTS: The total load lifted during the 12-week training was greater ($P < 0.05$) for CON ($143,262 \pm 57,972$ kg) than ECC ($111,678 \pm 51,225$ kg). 1-RM strength increased greater for CON (23-162%) than ECC (15-60%). ECC showed greater improvements for 6MWT ($18.7 \pm 15.4\%$), TUG ($-8.2 \pm 13.1\%$) and balance ($8.1 \pm 15.1\%$) when compared to CON ($16.5 \pm 4.9\%$, $-3.4 \pm 10.8\%$, and $3.2 \pm 13.8\%$, respectively). CR improved similarly between CON ($-16.0 \pm 13.0\%$) and ECC ($-14.0 \pm 10.2\%$). Body composition also improved similarly between groups including reduction in body fat (ECC: $-6.0 \pm 5.2\%$, CON: $-7.7 \pm 3.7\%$) and increase in lean muscle mass (ECC: $4.2 \pm 3.5\%$, CON: $3.8 \pm 4.0\%$).

CONCLUSION: The results showed that ECC training performed at lower intensities was more effective than CON training in improving physical function and induced similar changes in body composition to the CON group. These findings suggest that focusing on eccentric contractions when training is beneficial for adults with T2D.

Effects of Taking Extra Volume of Tablets Iron Supplement on The Value of Hemoglobin Concentrations in Collegiate Female Sprinters and Jumpers.

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Co-authors:

[OBJECTS] This research was to examine how extra volume of iron intake effects on daily physical condition of female athletes. To observe athlete's physical condition, body weight, hemoglobin (Hb) concentrations, intensity of training and a state of fatigue were measured in this research. Subjects of past studies about effects of iron intake on female athletes were distance runners. A few studies reported effects of iron supplement for sprinters or jumpers. [METHODS] The subjects were 11 collegiate female athletes, who were sprinters and jumpers. All subjects signed on an informed consent before participating in the research. The research had been carried out for 16 consecutive weeks. The 1st period, from the 1th to 7th week, all subjects had 1 tablet iron supplement, SUNACTIVE Fe produced by Taiyo-labo, which included 10 mg iron/ tablet. The 2nd period, from 8th to 15th week, the subjects took 3 tablets. For all subjects, the value of Hb, body weight, and the status of fatigue were measured once a week. Hb was measured by ASTRIM, a product of Sysmex Co., Ltd. ASTRIM is a device to measure hemoglobin concentrations with noninvasive blood vessel. The body weight was measured by a digital scale. The status of fatigue was answered by the visual analogue scale (VAS). Intensity of training was answered by the ratings of perceived exertion (RPE). During main practice of a session, all subjects pointed in the RPE scale. [RESULTS & DISCUSSION] Comparing initial value of Hb, since starting to take the supplement, Hb of most subjects was maintained above a standard value. According to the results of VAS and RPE, there was no significant change in Hb. Some of subjects had lower Hb than its past weeks, related to VAS and RPE. Recent studies warn that excessive intake iron causes a side effect like siderosis. However, sprinters and jumpers have a chance to lose Hb cause of highly impacts as ground contact. To maintain better physical condition, reconsideration about taking extra iron for sprinters and jumpers is needed.

Retention in Muscle Strength and Cycling Performance Following Resistance Training in Well-trained Cyclists: An Explorative Pilot Study

Author: Rni Blfoss

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Limited knowledge exists about the retention in muscle strength and power as well as cycling performance, following resistance training cessation in cyclists. The present study examined 3 and 6 weeks of retention following 8 weeks of concurrent resistance- and endurance (RE) training on maximal leg extensor power (LEP), isometric strength (MVC), late phase (200 ms) rate of force development (RFD), and 5-min all-out cycling performance immediately following 2-h submaximal cycling at 55% $\text{VO}_{2\text{max}}$. Nine competitive male road cyclists (65.5 ± 7.0 ml/kg/min) performed periodized resistance training (leg and core muscles, 4-10 RM) for 8 weeks as a supplement to their normal endurance (cycling) training, followed by 6 weeks of endurance training only (retention period). After 8 weeks of concurrent RE training LEP, MVC and RFD increased ($p < 0.05$) 12%, 15%, and 17%, respectively. Furthermore, 5-min all-out cycling power increased by 7% ($p < 0.05$). MVC remained elevated for 3- and 6-weeks following resistance training cessation ($p < 0.01$). Likewise, 5 min all-out cycling power was significantly elevated 6 weeks subsequent to resistance training cessation ($p < 0.05$). In conclusion, 8 weeks of concurrent RE training elicited improvements in 5-min all-out cycling performance following 2-h submaximal cycling, accompanied by gains in LEP, MVC and RFD. While LEP and RFD declined within 3 weeks during the retention period, MVC and 5 min all-out cycling performance remained elevated for 6 weeks following cessation of resistance training. Altogether, gains in cycling performance attained by concurrent RE training may be retained for at least 6 weeks after cessation of resistance training in competitive road cyclists. In practical terms, competitive road cyclists may focus on race-specific cycling training alone for prolonged periods of time (≤ 6 weeks) while still maintaining the benefits from previous periods of resistance training.

Pre-competition resistance training improves mechanical muscle function and athletic performance in national team ice hockey players

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The influence of a morning-based resistance training session on afternoon competition performance, also termed pre-competition training (PCT), has received increased attention, with experimental evidence pointing towards an increase in force- and power-related athletic performance (Cook et al. 2014). Our aim was to examine whether a morning PCT session leads to improved mechanical muscle function (i.e. increased knee extensor (KE) strength, rate of force development (RFD), counter movement jump (CMJ) power and lower limb stiffness (LLS)) 6 hours later. Sixteen Danish ice hockey players from the U20 national team (under 20 years) completed both PCT and non-training control testing days. Due to logistic reasons subjects were not randomized, hence 11 players started with the PCT protocol and 5 started with the non-training control. Participants performed: (1) a PCT protocol consisting of a submaximal squat-lift session (4 sets of 3 squat repetitions at 50%, 65%, 75% and 85% 1-RM) in the morning (9:00 h) followed by CMJ and unilateral isometric KE testing on an isokinetic dynamometer in the afternoon (15:00 h), and (2) a control (CON) trial consisting of afternoon (15:00 h) testing alone. Mechanical muscle function evaluated by CMJ was greater in PCT than control ($p \leq 0.05$), with increases in maximal jump height (+3.5%), LLS (+12.3%), and mean jump power (+4.7%). There were no significant differences in isometric KE strength or RFD between conditions. This study demonstrates that lower body resistance training performed in the morning may improve performances in some tests of mechanical muscle function and athletic performance measured 6 hours later (afternoon). In terms of practical implications, performing timed resistance training on days of competition (PCT) may be used to stimulate acute improvements in physical performance during match play.

Cook CJ et al., Morning based strength training improves afternoon physical performance in rugby union players. J Sci Med Sport. 2014

Effects of Hip Flexion Angle on The Nordic Hamstring Exercise High-density Emg Activity Completed in Submaximal and Fatiguing Conditions

Author: [Johan Lahti](#)

Co-authors: Andras Hegyi, Jean-Patrick Giacomo, Thomas Noule, Pauline Gerus, Jean-Benot Morin

Introduction: Understanding Biceps Femoris (BF_{Ih}) and Semitendinosus (ST) interplay within different conditions of commonly used exercises can be valuable for lower-limb injury management [1,2]. A commonly utilized exercise for the hamstrings is the Nordic hamstring exercise (NHE). In terms of BF_{Ih}/ST electromyography (EMG) ratios, holding the hip extended in the NHE is unexplored in different fatigue states. Therefore, the effect of hip flexion on BF_{Ih}/ST ratios between submaximal and fatiguing repetitions were explored.

Methods: 14 team sport athletes performed extended hip-joint (NHE0) and with hip flexed in 90 degrees (NHE90) NHE at 5-second eccentric, maximal speed concentric pace, on a novel device. Warm-up sets for either NHE0/NHE90 were completed until the subject felt an appropriate assistance was set for an 8-12 RM. After exhaustion, the same warm-up was completed for the second task. BF_{Ih} and ST EMG activities of the dominant leg were measured with high-density EMG electrodes recording 16 cm along each muscle. For analysis, the concentric portion of the first 2 repetitions were compared to the last 2.

Results: NHE0 showed a significant increase ($P=0.02$, $d=0.68$) in BF_{Ih}/ST ratios with fatigue (first reps: 0.96 vs. last reps: 1.11), but not in the NHE90 (0.80 vs. 0.90, $d=0.39$, $P=0.52$). In NHE0, Changes in BF_{Ih}/ST ratio were best explained by increases in BF_{Ih} (distal region 20%, proximal 18%, medial 14%), with a disproportionate increase in the distal vs medial region ($d=0.38$, $P=0.04$) but not the proximal vs medial/distal region ($d=0.24/0.10$, $P>0.05$).

Conclusion: NHE0 BF/ST ratios were higher, increasing with fatigue, explained best by disproportionate increases in activity of the distal region of the BF_{Ih}. These results give insight into strategies of manipulating hip angle in the NHE to change BF/ST EMG ratios. The efficacy of shifts in inter-and intramuscular EMG activity should be explored in terms of long-term adaptations.

Foam rolling improves jump performance following eccentric exercise in the leg extensors

Author: [Christopher Latella](#)

Co-authors: Eric Drinkwater, Christopher Wilsmore, Stephen Bird, Melissa Skein

Introduction: Neuromuscular recovery following training and competition is an important factor in human performance. Methods such as foam rolling (FR) are commonly employed as a recovery tool, however, the ability of FR to improve performance following specific muscle damaging eccentric (ECC) exercise remains unclear.

Methods: 11 male participants underwent 6×25 ECC contractions of the knee extensors to induce muscular damage. Immediately, 24, 48 and 72 h post-training performance outcomes; countermovement jump (CMJ) and maximal voluntary isometric contraction torque (MVIC) were measured. Additionally, mechanical variables: pressure-pain threshold (PPT), knee flexor range of motion (ROM) and mid-thigh circumference (MTC) were assessed. Measures of neuromuscular function included voluntary activation (VA), peak twitch torque (PTT), time to peak twitch (PTT_{time}) and rate of twitch torque development (RTD). Participants then spent either 15 min FR prior to each time point, or passive control (CON).

Results: The recovery of CMJ was greater for FR compared to CON at post-training (5.7%, $d=0.39$), 24 h (3.4%, $d=0.26$), 48 h (10.8%, $d=0.66$) and 72 h (8.6%, $d=0.54$), respectively, while PPT (11.8%-21.2%, $d=0.55-0.98$) and ROM (1.6%-3.49%, $d=0.22-0.42$), were also substantially improved with FR. VA improved, but only at 72 h (26.2%, $d=0.97$). No differences were observed for MVIC (-5.1%-4.2%, $d=-0.13-0.28$) or any other variables.

Conclusion: FR can improve explosive performance, but not maximal force during recovery. The increase in pain tolerance and ROM suggests that FR improves perceptual and mechanical outcomes, rather than neurological factors, which may contribute to the improvement in jump performance following damaging exercise. FR may be a useful during periods of frequent training and competition where inadequate recovery has the potential to cause a reduction in neuromuscular performance.

Week-to-week Changes in Neuromuscular Performance and Muscle Damage During A Competitive Microcycle In Youth Male Soccer Players

Author: Michal Lehnert

Co-authors: Zdenek Svoboda, Michal Botek, Mark De Ste Croix, Tereza Krakovska, Eliska Maixnerova, Milan Elfmark

In young players it is important to improve their training status and to ensure players' readiness for the game during the season. However, excessive training and/or competitive load may lead to fatigue-induced changes in the body and an increased risk of injury. The aim of this study was to explore the effects of match play and training load on neuromuscular and biochemical measures, and to assess the ability to re-perform at the end of a 2-match microcycle. 13 players (age: 13.6 ± 0.3 ; body height: 162.4 ± 9.8 ; body mass: 52.6 ± 11.4) were subjected to pre- and immediate post-match play measurements at the end of a previous microcycle and three measurements during a new microcycle: 48h, 96h and 153h post-match play (before match at the end of a new microcycle). During the measurement the following was determined: Reactive Strength Index (RSI), relative stiffness of the lower limb (STIFF_{rel}), creatine kinase activity (CK), and perceived muscle soreness (PMS). A significant effect of time was evidenced in RSI ($P < 0.001$, $h^2 = 0.354$), CK ($P < 0.001$; $h^2 = 0.642$), and PMS ($P < 0.001$; $h^2 = 0.463$). A post hoc analysis revealed a number of significant differences between the measurements. Especially after the match in the previous microcycle all parameters changed. Further, before the match in the midst of the new microcycle, significant changes in RSI, STIFF_{rel} and CK were observed. Although the new microcycle was physically demanding, the measurement before the match at its end did not indicate fatigue and consequently the players' ability to re-perform was not compromised. These findings indicate muscle damage and impairment of stretch-shortening cycle capability towards the end of the match in the previous microcycle and during training sessions and match-play in the midst of the new microcycle. To reduce the risk of injury it is recommended to decrease the training load in this part of the two-match microcycle.

Application of Isometric Strength Training for Enhancing Sports Related Dynamic Performance

Author: Danny Lum

Co-authors: Tiago Manuel Cabral dos Santos Barbosa

This review used a narrative summary of findings from 50 studies that focused on isometric strength training (IST), covering the training considerations that affect muscular strength adaptations and its effects on sports related dynamic performance. Neural and morphological adaptations post-IST were dependent on the volume, intensity, rate and duration of muscle contraction, and joint positions adopted during training. It has been shown that IST is a viable alternative mode of strength training that induced less fatigue than dynamic strength training, resulted in superior joint angle specific strength than dynamic strength training, and benefited various sports related dynamic performances including running, jumping and cycling. Coaches and athletes may include IST into their training regime 1) to avoid getting overly fatigue while still acquiring positive neuromuscular adaptations, 2) to improve the strength at a biomechanically disadvantaged joint position of a specific movement, 3) to improve sports specific movement that require mainly isometric contraction such as maintaining a horse stance during a karate kata performance or rugby scrum, and 4) when athletes are having limited mobility due to injuries or post-surgery. When the objective of training is to increase muscle hypertrophy, IST should be performed at 70-75% of maximum voluntary contraction (MVC) with sustained contraction of 3-30 s per repetition, and a total sustained contraction duration of >80-150 s per session for >36 sessions, while adopting a joint position that induces long muscle length. If the objective is to increase maximum strength, IST should be performed at 80-100% MVC with a sustained contraction of 1-5 s, and a total contraction time of 30-90 s per session, while adopting multiple joint angles or specifically targeted joint angle. It is also recommended for IST to be performed in a ballistic manner so as to maximize the improvement of rate of force development.

Effects of Two Isometric Strength Training Methods on Jump and Sprint Performances: A Pilot Study

Author: Danny Lum

Co-authors: Ranald Joseph

Studies have shown that isometric strength training (IST) performed explosively or with sustained contraction resulted in different neuromuscular adaptations. However, no study has compared the effects of different IST methods on jump and sprint performances. The aim of this study was to investigate the effects of explosive (Ex) vs explosive and sustained (ExS) IST on jump and sprint performances. Eighteen national floorball athletes (23.6 ± 3.2) were randomly assigned to control (Con) ($n = 6$), Ex ($n = 6$) and ExS ($n = 6$) conditions. Subjects completed 1 pre- and post-tests sessions which included countermovement jump (CMJ), 30-m sprint and isometric squat at 120° knee angle (IS120) tests, and 12 training sessions conducted twice a week over 6 weeks. All conditions performed the same upper limbs exercises with Con refraining from any lower limbs exercise. The Ex condition performed $4 \times 10 \times 1$ s isometric squats at 90° and 120° knee angles on the first and second session of the week, respectively. The ExS group performed $4 \times 5 \times 3$ s of the same isometric squat exercise with a 3 s sustained contraction. Isometric squat was executed explosively and at maximum force for both groups. Preliminary tests results showed no significant differences in all measured variables between groups. Results showed significant increase in IS120 peak force in Ex ($11.3 \pm 11.1\%$, $p \leq 0.05$) and ExS ($12.8 \pm 11.2\%$, $p \leq 0.05$). Significant improvement in jump height was observed in ExS ($11.2 \pm 8.5\%$, $p \leq 0.05$) only. No significant change in 30-m sprint time was observed in all groups. Post-test jump height was significantly higher ($p \leq 0.05$), and 30-m sprint time was significantly faster ($p \leq 0.05$), in ExS as compared to Con. No significant difference was observed for all measured variables between Ex and Con. Based on the findings of the current study, it is recommended to adopt the ExS method when performing IST for lower limbs.

The Efficacy of a Resistance Training Intervention to Improve Psychophysiological Wellbeing of Adolescent Girls

Author: Luana Main

Co-authors: Richard Kelly, Kris Hinck, Megan Teychenne

Background: Despite research into the different training modalities on the wellbeing and physical confidence of young girls, there remains a lack of data on the effects of resistance training in this population. The aim of this study was to investigate the effects of a seven-week close-kinetic chain, resistance training protocol on the physical self-concept of a cohort of adolescent girls. A secondary outcome was to measure the effects of the intervention in improving physical performance in speed, power and strength.

Method: Twenty-two adolescent girls (age 14-16) completed the training intervention. The Physical Self-Description Questionnaire (PSDQ) was assessed pre-, mid- and post-study to explore any changes in self-concept. The Multicomponent Training Distress Scale (MTDS) was used to monitor responses to training. Training consisted of a strength and hypertrophy session of 2-3 sets of 6-10 repetitions on 11 exercises, and a power session of the same structure but with only 3-5 repetitions. Physical performance was assessed at the same testing points using a vertical jump protocol, a drop jump task, and 5 and 10-metre sprint efforts.

Results: There were significant changes in Global Physical ($p = 0.001$), Strength ($p = 0.002$) and Appearance ($p = 0.007$) of the PSDQ subscales and Physical Symptoms ($p = 0.01$) of the MTDS across the three test periods. There were significant improvements in vertical jump ($p = 0.000$), drop jump ($p = 0.001$) and 5m ($p = 0.000$) and 10m sprint efforts ($p = 0.000$).

Conclusion: Closed kinetic chain resistance training exercises may elicit acute positive changes in physical and some psychometric measures in adolescent girls.

Prior knowledge of the weight lifted does not influence the ability to estimate repetitions to failure

Author: Sean Mansfield

Co-authors: Jeremiah Peiffer, Liam Hughes, Brendan Scott

Knowledge of the weight lifted, through visual or verbal cues, could influence the estimation of repetitions-in-reserve (RIR) and thereby decrease the efficacy of this technique. This study aimed to assess the accuracy of estimating RIR during the bench press at 60% and 80% of 1-repetition maximum (1RM) under blinded and non-blinded conditions.

Twenty trained males (>2 years' experience) were assessed for 1RM in the bench press, before being randomised into either a control (i.e. informed of the weight) or blinded (non-informed) condition. Participants then completed two separate trials in a randomised order; 1) a heavy-weight protocol (3 sets at 80% 1RM), and 2) a moderate-weight protocol (3 sets with 60% 1RM). During each set, participants provided a RIR score after 8 repetitions in the moderate-weight and 3 repetitions in the heavy-weight protocol, after which the set was continued to failure. Differences in estimated and actual RIR between sets and conditions (control v. blinded) were determined using a 3-way analysis of variance with repeated measures for the moderate- and heavy-weight conditions independently.

A Set x RIR interaction was observed with lower estimated compared with actual RIR in the moderate-weight protocol for set 1 (54.1%, $p \leq 0.001$) and the heavy-weight protocol for set 1 (38.3%, $p \leq 0.001$) and 2 (11.1%, $p = 0.046$). No Condition x Set x RIR interactions were observed for the moderate- ($p = 0.77$) or heavy-weight ($p = 0.59$) protocols. Additionally, no main effects for condition were observed in the heavy- ($p = 0.71$) or moderate-weight protocols ($p = 0.21$).

Knowing how heavy the weight is during resistance exercise did not influence the estimates of RIR. The ability to accurately determine RIR in the moderate- and heavy-weight protocols improved from sets 1 to 3. This finding indicates that estimation of RIR is enhanced under increased fatigue when an individual is estimating RIR at a closer point to actual failure.

Effects of Unilateral Accentuated Eccentric Iso-inertial Resistance Training on Muscle Mass and Function of The Trained and Untrained Legs

Author: Sergio Maroto Izquierdo

Co-authors: Kazunori Nosaka, Anthony J. Blazevich, Rodrigo Fernandez-Gonzalo, Javier Gonzalez-Gallego, Jos Antonio de Paz

Introduction: Significant cross-educational effects of eccentric resistance training have been reported. This study investigated functional and structural changes following unilateral iso-inertial resistance training with eccentric overload (EO-RT) for the trained and contralateral untrained legs.

Methods: Forty physically active university students (21.7 ± 3.4 years) were randomly placed into one of the three training groups and a control group without training ($n=10$ per group). Participants in the training groups completed 12 sessions of iso-inertial single-leg squat training (4 sets of 7 repetitions) over 6 weeks for the dominant leg. Resistance was generated either by an electric-motor device at two different velocities for the eccentric phase; 100% (EM100) or 150% (EM150) of concentric speed, or by a conventional flywheel device (FW). Thigh lean tissue mass by DEXA, unilateral leg press one-repetition maximum (1-RM), unilateral vertical jump, and unilateral muscle power at different percentages of 1-RM load were assessed before and after the 6-week training, and the changes were compared between the trained (TL) and non-trained legs (NTL).

Results: The three experimental groups showed similar increases ($p < 0.05$) in thigh lean tissue mass (2.5-5.8%), 1-RM (22.4-30.2%), unilateral vertical jump height (9.1-32.9%) and muscle power (8.8-21.7%) in TL. The magnitude of increase in 1-RM from pre- to post-training was 22.0-27.8% for NTL, and lean tissue mass increased ($p < 0.001$) for EM150 (3.5%) and FW (3.8%). Increases in unilateral vertical jump height (6.0-32.9%) and muscle power (6.8-17.5%) were also evident in NTL. The control group did not show any significant changes. Significant correlations ($p < 0.001$) between TL and NTL were observed for the change in 1-RM ($r=0.84$) and lean tissue mass ($r=0.76$), but not for other variables.

Conclusion: Strong cross-education effects were evident for thigh lean mass and muscle function (strength, power, vertical jump) after 6-weeks of EO-RT, suggesting that strength and function of a non-trained limb are augmented by EO-RT.

Identifying and Refining Mechanisms for Maximal Stretch-shortening Cycle Performance

Author: Jeff McBride

There are three possible mechanisms by which the stretch-shortening cycle (SSC) may be enhanced. The first involves muscle-tendon length changes with respect to storage and utilization of elastic energy, the second is stretch-reflex mediated force enhancement and the third is cross-bridge potentiation. All of these components are influenced by the amount of muscle activity immediately prior to and during the eccentric phase. Modulation of training may influence these variables and subsequently manifest in the optimization of performance.

A biomechanical comparison of the mid-thigh pull and countermovement shrug

Author: David Meechan

Co-authors: Timothy J Suchomel, John J McMahon, Paul Comfort

Weightlifting pulling derivatives can be performed from a static position (e.g. mid-thigh pull (MTP)) or initiated using a countermovement (e.g. countermovement shrug (CMS)), with the CMS likely to increase kinetic and kinematic outputs, due to the stimulation of the stretch-shortening cycle (SSC).

Purpose: To compare peak force (PF), peak power (PP), net impulse (IMP) and peak velocity (PV) of the system (lifter + load) during the propulsion phase of the MTP and CMS.

Methods: Eighteen men (age = 29.43 ± 3.95 years, height 1.77 ± 0.08 m, body mass 84.65 ± 18.79 kg) performed two repetitions of the MTP and CMS on a force platform with 40%, 60%, 80%, 100%, 120% and 140% of one repetition maximum (1RM) power clean. System velocity was calculated by dividing net vertical force by system mass at each time point and then numerically integrating the product using the trapezoid rule. Power was calculated by multiplying vertical force and velocity at each time point. The net vertical force-time record was integrated (trapezoid rule) to obtain IMP. PF, PV, PP and IMP were calculated during propulsion (positive velocity phase).

Results: The CMS resulted in significantly and meaningfully greater PF ($p \leq 0.001$, $d = 0.67-0.92$), PV ($p < 0.001$, $d = 1.87-2.91$), PP ($p < 0.001$, $d = 1.48-2.27$) and IMP ($p < 0.001$, $d = 1.23-1.70$) compared to the MTP at each load.

Conclusion: The stimulation of the SSC during the CMS results in greater PF, PV, PP, and IMP compared to MTP, at all loads.

Practical Applications: When looking to maximise PF, PV, PP and IMP, the CMS may be preferable to the MTP, as long as the athlete demonstrates appropriate postural control. However, it is likely that a MTP from blocks will still allow for technique maintenance & postural control with an increase in load.

Maximal Strength and Rate of Force Development of Hip Adduction and Abduction: Reliability of Measures from A Portable Dynamometer

Author: [Ricardo Mesquita](#)

Co-authors: Baslio Goncalves, Francisco Tavares, Joo Brito, Paulo Correia, Paulo Santos, Pedro Mil-Homens

Groin injuries are a major issue in sports involving kicking or quick changes of direction. Decreased hip adduction and abduction strength have been identified as risk factors for groin injury. The currently available methods to measure hip adduction and abduction strength are reliable but highly dependent on the evaluator skills. Furthermore, several studies have reported the reliability of maximal strength (maximum voluntary isometric contraction, MVIC) but up to now, far too little attention has been devoted to investigating the reliability of explosive strength (rate of force development, RFD). The aim of this research was to assess the reliability of a user-independent portable dynamometer that concurrently measures MVIC and RFD. Twenty-five healthy young participants performed maximal isometric hip adduction and abduction contractions in both sitting and supine positions. Measurements occurred in two different days separated by 48 to 72h. Test-retest reliability was calculated for MVIC and RFD. RFD was measured over time intervals from 0 to 50, 100, 150 and 200 ms relative to the onset of the voluntary contraction, as well as the maximal RFD. Considerably higher levels of reliability were found for MVIC when compared to RFD. A similar absolute reliability (minimal detectable change, MDC) of MVIC was observed between positions for adduction (MDC = 5.7% vs. 9.9%) and abduction (MDC = 3.8% vs. 6.5%). Reliability indices found in this study for MVIC are in line with those observed in earlier studies, whereas a considerably higher reliability was observed for RFD. RFD was considerably more reliable when using a time window of at least 100 ms and showed a smaller MDC in sitting for adduction (10% vs. 23%) and in supine for abduction (6% vs. 14%). This study showed that portable dynamometry can be used to concurrently measure adduction and abduction maximal and explosive strength in a reliable manner.

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Validity of sprint time measured using the camera functions of smartphones

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It is well-known that sprint ability is one of the important physical factors in sports. Photocell gates are usually used to accurately measure the sprint time. But photocell gates are often too expensive for many people to use as a daily measurement tool in actual sports fields. Therefore, the aim of the present study was to verify the validity of sprint time measured using the camera functions of smartphones. Subjects were six healthy men and women and sprinted about 15 m distance at various speeds. The sprint time was simultaneously measured using camera functions of two smartphones (iPhone X, Apple Co., Ltd.) with a sampling rate of 100 Hz and the photocell gates (Witty, MICROGATE Co., Ltd.). We cut off each captured image so that a 1280×41 pixels block remained at the center of each image and then further divided it vertically into 10×41 pixels blocks. The smartphones recognized brightness change of each block if a block changed its brightness more than 20% as compared with the previous frame and recorded the time when more than 12% of all blocks changed their brightness as a result of a subject passing in front of the smartphone cameras at the start and the end of sprinting. Two smartphones were connected with WiFi and calculated the sprint time by subtracting the time acquired at the start and the end of each sprinting. Pearson's product-moment correlation coefficient was calculated to validate the sprint time measured by the smartphones with the photocell gates. Correlation analysis revealed a significant high positive association between the sprint time measured by the smartphone and photocell gates ($r = 0.996$, $p < 0.01$). Thus, our system to measure sprint time using smartphones is considered to be an acceptable sprint time measurement tool.

Effects of eccentric versus concentric resistance training on muscle hypertrophy and maximal strength: New narrative review of literatures

Author: [Naotoshi Mitsukawa](#)

Co-authors: Kazunori Nosaka

Introduction: Some review papers have attempted to clarify the effects of eccentric resistance training on muscle hypertrophy and maximal strength in comparison to concentric and/or isometric resistance training. However, eccentric training was not classified into some categories based on the load in these review papers. This narrative review scrutinised the effects of isokinetic, isotonic pure-eccentric or concentric-eccentric overload resistance training on muscle size and/or muscle fiber area, and maximal eccentric, isometric, concentric strength in comparison to concentric resistance training.

Methods: Twenty-one papers (24 results) on whole muscle hypertrophy, eight papers (7 results) on muscle fiber area, and 34 papers (37 results) on muscle strength were identified and included in this review.

Results: Seven out of 11 results showed no significant difference in muscle size increases between isokinetic eccentric ($7\pm 3\%$) and concentric training ($5\pm 4\%$). Six out of 7 results showed no significant difference in muscle size between pure-eccentric overload ($5\pm 3\%$) and pure-concentric training ($5\pm 2\%$). Four out of 6 results showed no significant difference in muscle size between concentric-eccentric same load ($4\pm 5\%$) and concentric-eccentric overload training ($4\pm 4\%$). However, at muscle fiber level 3 out of 7 studies showed greater type II fibre hypertrophy after eccentric ($21\pm 13\%$) than concentric training ($10\pm 7\%$). Regarding maximal strength, 12 out of 17 results showed that eccentric strength increased greater after isokinetic eccentric ($35\pm 28\%$) than concentric training ($15\pm 11\%$). Eleven out of 17 results showed no significant difference between isokinetic eccentric ($16\pm 8\%$) and concentric training ($18\pm 13\%$) for their effect on concentric strength. Six out of 7 studies reported no significant difference between pure-eccentric overload ($15\pm 6\%$) and pure-concentric training ($20\pm 12\%$) for increases in isometric strength.

Conclusion: These results suggest that eccentric training effects on muscle hypertrophy and strength are dependent on its intensity, and do not appear to be largely different from concentric training effects except for eccentric strength.

Force-velocity-power Profiling: New Concepts, New Methods, New Insights into Jump and Sprint Performance

Author: JB Morin

Prof Morin will present some recently published biomechanical concepts and methods, and their direct implementation in high-level sports training contexts. This innovative force-velocity-power profiling approach of athlete's physical capabilities in explosive movements (mainly jumping and sprint acceleration) will be described through the underlying theoretical concepts, the classical laboratory measurements, and recently validated field methods using simple inputs and devices such as smartphone applications. Examples of applications to sports training will include individualised, optimised training for jumping and sprint acceleration performance, as well as injury management. All concepts, methods and applications discussed will be supported by published scientific evidence

The influence of anger on muscle strength and dexterity

Author: Yuki Murata

Co-authors: Yu Toyasaki, Keisuke Nakade, Ryoji Uchiyama, Kazuki Ashida, Saiki Terasawa, Koji Terasawa

Introduction: During sports games and matches, it is important for us to keep our mental in good condition. Many studies have reported that mental conditions influence athletic performance. However, only a few studies have examined the effect of anger on muscle strength and dexterity. This study investigated how feeling of anger would influence muscle strength and dexterity.

Method: Nine university students (20.7 ± 1.1 y) participated in this study. The first method to increase anger was to write the most anger experience in their life on a paper. The second method was that the investigator kept saying what was uncomfortable for each participant for 30 seconds. The third method was that the investigator continued spraying mist on the face of each participant for 30 seconds. Before and after each method shown above, hand grip strength and a dexterity test (grabbing a bean in a plate with a pair of chopsticks and placing it to a different plate next in 30 seconds). Hand grip strength and dexterity test values after each condition were compared with a control condition without any intervention using paired-t tests.

Results: Grip strength in the control condition was 30.2 ± 10.0 kg, which increased ($P < 0.05$) after the first (32.9 ± 10.3 kg) and second (32.3 ± 10.5 kg) interventions, but not after the third intervention (32.6 ± 13.9 kg). Regarding dexterity, the number of beans moved from one dish to the other was 21.0 ± 2.0 for the control condition, which decreased ($P < 0.01$) after all three interventions (first: 15.9 ± 3.1 , second: 17.0 ± 2.2 , third: 16.6 ± 3.7) without a significant difference among three conditions.

Conclusion: These results showed that anger increased muscle strength, but decreased dexterity. This may suggest that anger control during sports games and matches is important for athletic performance that requires dexterity.

Why would cancer patients do weight training?

Author: Rob Newton

Less than a decade ago the clinical recommendation for people with cancer was to rest and avoid strenuous physical activity. In the Australian guidelines published by our team in 2009 based on a growing body of literature our recommendation was that patients should try to be active on most if not every day of the week and to perform two or more resistance training sessions. Over the past 10 years numerous high-quality epidemiological studies and randomised controlled trials have been completed in a variety of cancers and at various stages of disease. Increasingly these trials have involved resistance training as part or entirely the intervention. The rationale for resistance training by cancer patients is quite convincing due to the observed comorbidities that these patients face.

Muscle and bone loss are highly problematic for many cancer patients in particular men receiving testosterone suppression therapy for prostate cancer. Our team recently published a paper reporting that a highly targeted exercise prescription involving high intensity resistance training combined with impact loading (plyometrics) significantly reduced bone loss in these patients whereas a combination of aerobic and the same resistance training program was ineffective. This demonstrates the highly specific nature of exercise medicine prescription in cancer management. We have also demonstrated that resistance training can prevent muscle loss and in the majority of patients actually drive muscle hypertrophy even when they are receiving highly catabolic therapies such as chemo, radiation and hormone therapy.

Recently it has been reported that patients with low muscle mass experience higher toxicities and side-effects from chemotherapy. In one large study of patients with breast cancer there was a strong relationship between muscle mass and survival. It is becoming increasingly evident that high quantity and quality of muscle is important for controlling morbidity and mortality of cancer patients and thus a priority in exercise prescription is targeted resistance training applied at all stages of the cancer continuum.

There is accumulating evidence that physical exercise actually influences cancer biology through a range of mechanisms including hormonal, vascular, endocrine, epigenetics, and immune. Appropriate activation of muscle tissue stimulates the production of natural killer cells and release of cytokines which combined with increased blood perfusion in the tumour causes a strong anti-cancer effect through enhanced immune function.

Cancer patients with more advanced disease exhibit sarcopenia, low neuromuscular strength and power with resulting functional deficit. These patients do not tolerate aerobic exercise but do respond well to resistance training and it has been demonstrated to be feasible even in patients with metastatic disease that have completed extensive surgery, chemo and radiation therapy. It is critical that exercise

prescription for cancer patients is tailored targeting the specific morbidities and mortality risk in a prioritised strategy. For many cancer patients, resistance training will form a significant component of their overall management and care.

Eccentric Exercise as Medicine

Author: Ken Nosaka

Unaccustomed exercises consisting of lengthening (eccentric) muscle contractions (eccentric exercises) induces muscle damage characterised by prolonged decreases in force generating ability, delayed onset muscle soreness (DOMS), and increased levels of muscle proteins such as creatine kinase (CK) in the blood. However, skeletal muscles adapt rapidly after the initial exposure to eccentric exercise, and the magnitude of muscle damage induced by subsequent bouts of the same exercise is significantly reduced. This adaptation is known as the repeated bout effect and is represented by faster recovery of force generating ability, attenuated DOMS, and smaller increases in CK in the blood. The protective characteristics are conferred by “non-damaging” exercises such as low-intensity eccentric contractions and maximal isometric contractions at a long muscle length, and also transferred to the homologous muscle of the contralateral (non-exercised) limb. Thus, muscle damage should not discourage people from performing eccentric exercises. When eccentric exercise is repeated over time, it increases muscle strength, muscle mass and functional physical fitness, and improves insulin sensitivity and blood lipid profiles much greater than exercises mainly consisting of concentric muscle contractions (concentric exercises). For example, we (Chen et al. MSSE 2017) have reported that walking down stairs (eccentric exercise) improves muscular function, functional physical fitness, cardiovascular function, insulin sensitivity and blood lipid profiles of elderly obese women much greater than walking upstairs (concentric exercise). It should be noted that descending stair walking is less metabolically demanding than ascending stair walking, making it ideal for older people or those with limited mobility. It is well documented that exercise is medicine, but the effects of eccentric exercise training have not been in the main focus yet. In the presentation, potential benefits of eccentric exercise interventions will be discussed, and it will be proposed that eccentric exercises should be used more extensively in exercise medicine.

Physical performance and serum hormone concentrations during military survival training (SERE)

Author: Tommi Ojanen

Co-authors: Heikki Kyrlinen, Keijo Hkkinen

Purpose: To investigate changes in neuromuscular performance, body composition and serum hormone concentrations during military survival training.

Methods: Twenty-six (age 20 ± 1 yrs., height 180 ± 7 cm, body mass 76.1 ± 10.4 kg) male soldiers voluntary participated in the study. The SERE course was approximately 2 weeks in duration and consisted of garrison and field training phases. Blood samples were drawn and assayed for serum testosterone (TES), cortisol (COR), insulin-like growth factor-1 (IGF-1), sex hormone binding globulin (SHBG), adrenalin (ADR) and noradrenalin (NOR). In addition, body composition, shooting performance and several physical performance tests (e.g. maximal isometric force, power and endurance) were measured before (PRE) and after (POST) the field phase. Daily diaries were collected to follow amount of sleep, workload and mood states of the soldiers.

Results: Significant declines ($p < 0.001$) were observed in TES (-75.9%) and IGF-1 (-57.6%), and increases in COR (+30.6%), SHBG (+35.0%), ADR (+154%) and NOR (+344%). Fat mass (-29.2%) and total body weight (-4.5%) decreased significantly in the POST measurements, but no significant change was observed in skeletal muscle mass. All physical performance tests decreased significantly after the SERE course except for maximal isometric leg extension force. Shooting score decreased (-10.6%) significantly in the prone but not in the standing position.

Conclusions: The present results revealed that the cumulative effects of food restriction, sleep deprivation, and the highly stressful SERE course resulted in significant changes in serum hormone concentrations, body composition, physical performance and shooting score in the prone position. It seems that especially sleep deprivation influences prone shooting ability and, therefore, it is important to have, at least, some sleep to maintain the high level in shooting. The changes in serum hormone concentrations and physical performance were so drastic, thus it is recommended to have a proper recovery period after the SERE course before returning to normal service.

The 2 Minute Loaded Repeated Jump Test: Longitudinal Anaerobic Testing in Elite Alpine Ski Racers

Author: Carson Patterson

Co-authors: Hans-Peter Platzer, Christian Raschner

This study investigated the 4-year development of anaerobic power and capacity in Austrian elite female alpine ski racers and examined the relationship between the 2-minute loaded repeated jump test (LRJT) results and ski racing performance (International Ski Federation (FIS) points). Ten female Austrian elite ski racers were tested prior to four racing seasons. The LRJT consisted of 48 loaded countermovement jumps (LCMJs) with a barbell load equivalent to 20% bodyweight. Before the LRJT, the maximal body mass normalized average power of a single LCMJ (P_{MAX}) was determined. The mean jump power was calculated across all jumps in the test (P_{0-120}). Anaerobic power (P_{MAX}) in season 2 ($32.3 \pm 2.3 \text{ W}\cdot\text{kg}^{-1}$) significantly improved over season 1 ($30.5 \pm 2.3 \text{ W}\cdot\text{kg}^{-1}$) but there were no further differences between seasons, with season 3 at $33.5 \pm 3.4 \text{ W}\cdot\text{kg}^{-1}$ and season 4 at $33.6 \pm 3.0 \text{ W}\cdot\text{kg}^{-1}$. Anaerobic capacity (P_{0-120}) increased up to season 3 by 9.2% (27.1 ± 2.8 to $29.6 \pm 2.4 \text{ W}\cdot\text{kg}^{-1}$) but was significantly higher only when comparing season 4 to seasons 1 and 2. FIS points changed significantly, from 18.1 ± 8.2 in season 1 to 8.4 ± 4.8 in season 4 (lower FIS points indicates better racing results). FIS points had a positive relationship with P_{MAX} ($r = -0.73$) and P_{0-120} ($r = -0.64$) only in season 4. Improvements in FIS points from year to year did not correlate with seasonal increases in LRJT results. In conclusion, anaerobic power improved only after season 1, and anaerobic capacity changes were evident only in season 4. Ski racing performance (FIS points) correlated with LRJT test results in only season 4. The LRJT can monitor a ski racer's anaerobic power and capacity but cannot predict ski racing performance.

Supramaximal Eccentrics Versus Traditional Training in The Bench Press: A Pilot Study with An Automated Training Device

Author: Carson Patterson

Co-authors: Lukas Hoellrigl, Antonio Perez, Christoph Ebenbichler, Roland Luchner, Simon Walker, Christian Raschner

Many athletes employ supramaximal eccentric training (SME) to improve maximal strength, which in turn may improve performance. SME is potentially dangerous and requires multiple spotters. The Intelligent Motion Lifter (IML) is a safe automated SME device, which requires one operator. IML allows three-dimensional bar movement during the eccentric portion of the lift and requires no external load adjustments during training. Athletes are currently training with the IML, but to date the training efficacy of the IML has not been investigated. The purpose of this study was to compare one repetition maximum (1RM) bench press after 6 weeks of combined SME and traditional training with 1RM bench press after 6 weeks traditional training. Sixteen elite athletes were randomly split into two groups: the traditional group (TRADG) and the combined group (COMBG), which combined SME (eccentric only sets (ECC)) and traditional training. Bench press training occurred once per week, all other strength training (total 4 per week) was identical for both groups. TRADG training involved 7 warm up sets then 1 x 85%, 1 x 90%, 3 x 82% and an all-out set with 80%. Loads are expressed as % 1RM. TRADG loads were increased over 6 weeks to 1 x 101%, 1 x 107%, 3 x 99% and all-out at 80%. COMBG had the same warm up then ECC 3 x 95%, 1 x 90%, ECC 3 x 100%, 1 x 94% and no all-out set. COMBG increased to ECC 2 x 107%, 1 x 104%, ECC 1 x 112%, and 1 x 108%. Preliminary results showed TRADG 1RM improved from 133.8 ± 18.5 (mean \pm SD) to 140.0 ± 17.5 kg and COMBG improved from 131.9 ± 26.2 to 140.8 ± 23.7 kg. T-tests showed no differences in 1RM improvements, but total training volume was significantly less in COMBG.

Muscular Responses to Single Hypertrophic and Power Loadings Are Highly Individual

Author: Heikki Peltonen

Co-authors: Juha Ahtiainen, Keijo Hkkinen

It is well known, that chronic resistance training induces positive adaptations to force production and muscle mass. However, the gains due to the identical training program are highly individual, although the population is homogenous (e.g. training status) (1,2). Acute neuromuscular responses to a single resistance exercise bout might in part explain these differences. Nine men (31 ± 6 years) were divided into two-groups based on their muscle swelling (muscle thickness by ultrasound) at 48-hours after hypertrophic (HYP, 5x10RM with 2min rest) and power (POW, 10x5x50%1RM load with 3min rest) loadings. Seven days or more were between the loadings and all previously untrained subjects finished the 4-week preparatory resistance training period before the first loading.

The highest one third increased their muscle thickness $11 \pm 7\%$ (vs. $1 \pm 2,6\%$, $p < 0.05$) after HYP and $6 \pm 2,3\%$ (vs. $3 \pm 1,9\%$, $p < 0.05$) after POW compared to the pre-level. The highest increases in muscle thickness occurred in different individuals after HYP and POW. When compared to other subjects, increases in muscle thickness in the highest third following POW were associated to higher neural fatigue (voluntary activation down to $87 \pm 2,2\%$ vs. $93 \pm 2,9\%$, $p < 0.05$) and muscle performance decrements (squat jump $-12 \pm 7,9\%$ vs. $-4 \pm 4,9\%$, $p < 0.05$; isometric leg extension $-31 \pm 2,8\%$ vs. $-10 \pm 12,5\%$, $p < 0.001$). In addition, their testosterone levels after loading was decreased ($-6 \pm 16,8\%$ vs. $13 \pm 6,7\%$, $p = 0.08$) compared to others. HYP high-responders showed a trend of lower testosterone/cortisol-ratio immediately after the loading ($0,0164 \pm 0,0013$ vs. $0,0269 \pm 0,0067$, $p = 0.08$). However, HYP-loading caused huge overall fatigue in all performance parameters, which might hide individual differences between high-responders and others.

Increased muscle thickness was following acute resistance exercise is induced by myofibrillar disruptions and, thus, inflammation processes and cell swelling. During the 48-hour recovery, inflammation process should be the most active based on previous findings in creatine kinase levels. Resistance exercise-induced inflammation process could be the one of the potential factors in the muscle hypertrophy due to resistance training (3) and possibly explain in part inter-individual variation in resistance training responses. Acute neuromuscular responses following POW may be useful indicators for specific neuromuscular adaptations to resistance training.

Relationship Between Maturation, Strength, Movement Competency and Motor Skill Performance In Adolescent Males

Author: Andrew Pichardo

Co-authors: Peter Maulder, Craig Harrison, Rohan Kandoi

Despite the limited research available, understanding how maturation, strength and movement skill influence long-term athletic development is crucial when working with young people. Therefore, the purpose of this study was to examine the relationships between maturation, strength, movement competency and motor skill performance in young males. One-hundred and ten adolescent males (mean \pm *SD*; age 13.8 ± 0.6 y; height = 165.8 ± 9.4 cm; mass = 57.1 ± 13.9 kg; maturity offset = 0.1 ± 0.9 y) were tested for movement competency (resistance training skills battery, RTSB), strength (isometric midthigh pull, IMTP), speed (10, 20, 30 m sprint), power (horizontal jump, HJ; vertical jump, CMJ; seated medicine ball throw, SMBT) and repeat sprint ability (RSA). Results showed that maturity offset had small correlations with CMJ ($r = 0.25$), moderate correlations with speed ($r = -0.31$ to -0.35) and HJ ($r = 0.33$), and strong correlations with absolute strength ($r = 0.70$) and SMBT ($r = 0.76$). Relative strength showed small to large correlations with all motor skill variables ($r = 0.27$ - 0.61), whereas absolute strength was significantly correlated with speed, power and RSA ($r = 0.29$ - 0.83). The RTSB score showed small to moderate correlations with RSA ($r = 0.27$) and 20 and 30 m sprint performance ($r = -0.34$). Relative strength was the strongest predictor for all sprints (adjusted $R^2 = 0.38$ - 0.40), CMJ (adjusted $R^2 = 0.16$) and RSA (adjusted $R^2 = 0.27$), whereas absolute strength was strongest for HJ and SMBT (adjusted $R^2 = 0.21$ and 0.70 , respectively). Maturity offset further explained sprint, CMJ and SMBT performance whereas RTSB did not help predict the performance of any dependent variables. Strength, movement competency and maturity are important considerations for motor skill performance, but strength may be most important and should be developed early on using appropriate training recommendations.

Muscle Action of Strength Assessment Influences Performance Ranking in Ankle-dominant Athletes

Author: Paige Elizabeth Rice

Dancers and endurance runners employ high volumes of cyclical actions predominantly about the ankle-joint that may induce preferential movement strategies and strength levels for optimal performance. Although both athletic populations are exposed to high eccentric loading, the specific modality of each activity may result in differential adaptations and realization of strength. The purpose of this study was to examine strength profiles between dancers and runners during isometric and isokinetic tasks around the ankle. Well trained adult female dancers ($n = 8$) and runners ($n = 8$) with a minimum of ten and five years of experience, respectively, provided informed consent and participated in this study approved by the University ethics committee. Subjects performed two trials of maximal voluntary isometric plantarflexion prone on a dynamometer at angles of -10° , 0° , 10° , 20° and 30° . Subjects then performed three trials of maximal concentric and eccentric contractions at $60^\circ/\text{sec}$, $120^\circ/\text{sec}$ and $180^\circ/\text{sec}$ from -10° to 30° of ankle angle. Peak torque from each trial was normalized to body mass and the total average from each subject's isometric, concentric and eccentric strength was determined. A two-way ANOVA test with a Sidak correction was performed between groups for isometric, concentric and eccentric strength tasks. No significant differences ($p = 0.44$) were found between dancers and runners for any strength measure, however, large deviations from the mean were observed in each condition leading to further statistical analysis. A one-way Kruskal-Wallis test was then implemented to examine rank order differences between isometric, concentric and eccentric strength measures. Significant differences ($p < 0.001$) were observed between all conditions, indicating a single measure of strength did not equally measure the rank of participants. Therefore, individuals with comparable movement patterns may have unique profiles of eccentric, isometric and concentric strength that should be considered when assessing different muscle actions.

Effects of low intensity strengthening intervention for senior adults.

Author: Kim Rivera

Co-authors:

Background/Aim: The purpose of this study was to evaluate the impact of a Lower Extremities and Upper Extremities strength using a low intensity strengthening protocol for clients with the history of stroke and currently suffering from insomnia.

Methods: Thirty senior adults (15 male, 15 female) aged 65- 75 years old with a medical diagnosis of stroke and insomnia. The Pittsburgh Sleep Quality Index (PSQI) questionnaire was administered twice (before the start and after the end of the study). A low intensity strengthening intervention was developed and targeted a goal of 30 minutes daily for 4 weeks.

Results: The Low intensity strengthening intervention improved the participants PSQI global score, sleep latency and sleep duration. The Low intensity strengthening intervention significantly improved the PSQI global score and perceived sleep quality.

Conclusion: Low intensity strengthening intervention might reduce the sleep latency and increase total sleep duration on stroke survivor population.

Isokinetic dynamometer muscle strength measures do not represent the effects of eccentric resistance training of the knee extensors on muscle function changes in older adults

Author: [Wafina Rohadhia](#)

Co-authors: Neda Kiani Mavi, Favil Singh, Desmond Menon, Kazunori Nosaka

INTRODUCTION: Muscle strength measures performed by an isokinetic dynamometer are widely used to assess muscle function of lower extremities, but do not correlate with one repetition maximum (1RM). This study investigated the effects of eccentric resistance training (ECC-RT) of the knee extensors on maximal voluntary isometric (MVIC) and isokinetic concentric contraction torque (MVCC), knee extension 1RM and repeated chair rise (CR) performance, and their relationships for the magnitude of changes from pre- to post-training performed by older adults.

METHODS: Ten sedentary older (62-78 y) men and women performed ECC-RT of the knee extensors using a Cybex knee extension machine for 16 sessions over 8 weeks. The training load was gradually increased from 10%-100% of concentric 1RM, and the participants lowered the weight from a knee-extended to a flexed position in 3-s, and the investigators lifted the weight back to the knee extended position. MVIC torque at 70° knee flexion, and MVCC torque at 180°/s were measured for the right leg on an isokinetic dynamometer. Knee extension 1RM and the number of CR from sitting to full standing position in 30-s were also measured. These measurements were taken at baseline and after 8-weeks of training, and the correlations between the magnitude of changes in these variables were analysed by Pearson's product-moment.

RESULTS: 1RM increased by 42-120% ($p < 0.05$) among participants, but MVCC (0-57%) and CR (0-43%) showed smaller ($p < 0.05$) increases, and MVIC (0-28%) did not show a significant increase ($p = 0.114$). No significant ($p > 0.05$) correlations were found between 1RM and CR ($r = -0.359$), MVIC ($r = -0.351$) and MVCC ($r = 0.001$) for their magnitude of changes. Similarly, no significant ($p > 0.05$) correlations were found between CR and MVIC ($r = -0.134$) and MVCC ($r = -0.149$).

CONCLUSION: These results show that the isokinetic dynamometer muscle strength measures and CR did not represent the effect of ECC-RT indicated by 1RM in older adults.

Comparing Pqct Muscle and Adipose Measurement Errors with Two Commonly Used Image Processing Methods

Author: [Grant Rowe](#)

Co-authors: Anthony J. Blazeovich, G. Gregory Haff

Purpose Resistance training triggers numerous physiological adaptations that improve physical performance and reduce the risk of developing certain diseases. In particular, the enlargement of muscle size is a common objective as it contributes to improvements in muscular strength. Although not commonly considered, resistance training may limit the accumulation of intramuscular adipose tissue (IMAT), a factor known to predispose metabolic and cardiovascular disease. Thus, the reliable monitoring of muscle size and adipose content is essential to ensure training efficacy and accurate diagnosis of certain diseases. A frequently used technique to assess these properties is peripheral quantitative computed tomography (pQCT). However, there are different image processing methods used to analyse these properties which can make interpreting pQCT results difficult. *Methods* pQCT was used to scan the non-dominant upper arm of 17 participants on four consecutive days. The images were processed using an installed macro onto the Stratec software (XCT-3000; Germany) and with the pQCT distribution analysis plugin on ImageJ. Muscle and adipose measurement errors were calculated by determining the least significant change (LSC), which represents the smallest percentage change considered statistically significant with 95% confidence. *Results* Both image processing methods had low LSC scores for lean muscle area (ImageJ = 2.2%; Stratec = 2.0%) and muscle density (ImageJ = 1.1%; Stratec = 1.0%) while the ImageJ analysis (2.2%) had a lower LSC score than the Stratec analysis (7.8%) for muscle cross-sectional area. In contrast, the Stratec analysis (4.1%) had a substantially lower LSC score when compared to ImageJ analysis (104.7%) for IMAT area. *Conclusion* The two image processing methods have similar measurement errors for some properties while performing better or worse on others. Consideration of these measurement errors ensures that decisions relating to an individual's training progression or health status are reflective of 'real' outcomes rather than being influenced by analytical variations.

Determining force onset during the countermovement jump and its effect on the calculated rate of force development

Author: Sofyan Sahrom

Co-authors: Anthony Blazevich

Introduction: The rate of force development (RFD) measured during a countermovement jump (CMJ) has been used as a critical variable describing complex, multi-joint function. However, there is inconsistency in how RFD is calculated between studies. In particular, the definition of the time of 'force onset' varies considerably and is typically not a correct reflection of the true point at which the rapid increase in force (i.e. force development) occurs in the jump. The purposes of this study were to develop a methodology to identify the true start of force development during a CMJ and to then determine its effect on the calculation of average (RFD_{avg}) and peak (RFD_p) RFD.

Methods: Three-dimensional mechanics and muscle activity of the lower limbs were collected during CMJs with no arm swing in 32 physically active males. Electromyograms (EMG) were recorded from eight lower-limb muscles and the EMG onset (EMG_{on}), defined as the first point at which a rapid increase in EMG was observed subsequent to the initiation of the countermovement (i.e. dip) phase was used to identify the start of the force development, i.e. the start of the RFD period. The EMG_{on} method of determining force onset was compared with the (1) traditional method, i.e from the start of the countermovement phase, and 2) lowest force recorded during the CMJ (usually in the early countermovement period).

Results: Agonist muscle activity onset occurred approximately 170 to 240 ms into the countermovement phase. Differences were observed in both RFD_{avg} and RFD_p variables between the EMG_{on} and traditional methods. These differences led to a significant difference in the rank order of the subjects within the cohort between these two methods.

Conclusion: Our findings indicate that the traditional method of determining rate of force development is inaccurate as force onset occurs much later. The EMG_{on} and lowest force methods might be more accurate in the calculation of the rate of force development during CMJ.

Characterizing the Metabolic and Cardiovascular Intensity of Walking Football in Southeast Asian Women

Author: Dee Dee Ayra Salle

Co-authors: dan heil, Robert Newton

In 2017, the *Walking Soccer for Healthy Asia* program was initiated to encourage Singaporean and Malaysian women to adopt a more physically active lifestyle by training and competing in a walking soccer league. Given that both countries have relatively high incidence of obesity and obesity-related comorbidities when compared to other South-East Asian countries, this program represents a publicity-driven community intervention designed to encourage adult women of all ages to participate in a team sport that is traditionally dominated by men. This study sought to characterize the cardiovascular demands and metabolic intensity of Southeast Asian women competing in walking football matches to determine the sports' suitability for promoting physical health. It was hypothesized that both cardiovascular and metabolic intensity measures ($\geq 65\%$ HR% and ≥ 3.0 METs, respectively) would meet or exceed established thresholds for improving fitness and health. Methods: Women's teams from Singapore (Mean \pm SD: 42 \pm 11 yrs age; 29.2 \pm 7.0 kg/m² BMI; n=14) and Malaysia (40 \pm 10 yrs age; 32.9 \pm 5.7 kg/m² BMI; n=8) competed in two successive matches within a single day during which measures of heart rate (HR) and GPS (from portable handheld device) were recorded for each player, while relative HR was computed as a percent of each player's age-predicted maximal HR (HR%, %). The GPS data were later converted to walking distance and metabolic intensity (i.e., metabolic equivalents, or METs). One-sample t-tests at the 0.05 alpha level were used to compare variables to their respective thresholds. Results: Both Malaysian and Singaporean teams had mean relative HRs (91-95% of HRMAX [P=0.008] versus 77-80% of HRMAX [P<0.001], respectively) that exceeded the 65% threshold for improving cardiovascular fitness. Both teams also maintained an average metabolic intensity that was statistically similar to the 3.0 MET threshold that decreases one risk for non-communicable diseases (3.2 \pm 0.9 METs [P=0.0510] versus (3.3 \pm 1.0 METs [P=0.288], respectively), and both teams walked an average of 2.2-2.4 kms/match. Conclusions: These results support the idea that competitive walking football is of sufficient intensity to promote positive changes in both cardiovascular and metabolic fitness in this population of Southeast Asian women.

Key Words: GPS, heart rate, MET, Singapore, Malaysia, Physical Activity

Usefulness of The Modified Double Leg Lowering Test

Author: Momoko Sato

Co-authors: Rieko Kuramochi, [Gaku Tokutake](#), Shota Enoki, Taisei Hakozaiki, Yuki Koto

Objectives: Double Leg Lowering Test (DLLT) assesses the ability of trunk muscles to stabilize the pelvis against an external load imparted by the lower extremities as they are lowered from a vertical starting position. DLLT is often used for athletes and patients with low back pain. However, some subjects cannot raise the legs to the vertical starting position because of muscle tightness in the posterior lower limbs. Therefore, we devised a modified DLLT (mDLLT) that is performed at the knee flexion position, which is aimed at relieving the muscle tightness in the posterior lower leg. The purpose of this study was to clarify the proportion of subjects who can perform DLLT and to investigate the reliability of both methods.

Design: Cross-sectional study

Subjects: Seventy-one Japanese adults (52 male, 19 female, age: 21.31 ± 1.45 years) who could perform DLLT and mDLLT without pain.

Measurements: DLLT and mDLLT measurements were obtained twice by two examiners over two days. A correlation coefficient for correlation between the measurements of both tests and an intraclass coefficient were calculated.

Results: The proportion of subjects who could perform DLLT was 45% (male: 28.8%, female: 89.5%). Intra-rater reliability of both methods was "substantial" (ICCDLLT (1,1) = 0.640, ICCmDLLT(1,1) = 0.670), as well as their inter-rater reliability (ICCDLLT(2,1) = 0.757, ICCmDLLT(2,1) = 0.646). There was a significant positive correlation between measurements obtained by both methods ($p < 0.01$, $r = 0.815$).

Conclusions: The DLLT is not effective for subjects who have muscle tightness because they cannot raise the legs to the vertical starting position. The reliability of mDLLT was similar to that of DLLT, and the correlation between both methods was significantly positive. Therefore, we recommend using the mDLLT because this test can measure similarly as DLLT and anyone can perform the test.

Associations Between Cancer-related Fatigue and Muscle Strength in Breast Cancer Survivors Following 12 Weeks of Supervised Strength Training

Author: Moritz Schumann

Co-authors: Lars Gerland, Susanne Frisse, Nils Freitag, Wilhelm Bloch, Freerk T Baumann

Regular strength training may improve physical functioning and attenuate the development of cancer-related fatigue (CRF) in cancer survivors. This study aimed to investigate possible associations between changes in muscle strength and CRF in cancer patients following 12 weeks of supervised resistance training during neo-adjuvant chemotherapy.

Thirty-seven breast cancer patients were randomized into an intervention (IG, $n=19$, 50 ± 8 years) or control (CG, $n=18$, 47 ± 9 years) group before commencing with chemotherapy. Strength training was performed twice weekly for 45-60 minutes, consisting of 2-3 sets with 70-80% of 1RM for lower and upper extremities. CRF was assessed by the multidimensional fatigue inventory (MFI-20), while torque was measured by isometric and isokinetic knee and elbow extensions and flexions (knee: 36° and 63° , $0-80^\circ$ at 60°s^{-1} ; arms: 47° and 93° , $0-140^\circ$ at 30°s^{-1}). A strength index (SI) was calculated by averaging the accumulated strength values of the left and right extremities.

Changes in CRF remained statistically unaltered but were highly individual both in IG ($-1.9\pm 39.5\%$, range $-61.9-107.3\%$) and CG ($26.5\pm 30.6\%$, range $-30.9-73.4\%$). Changes in leg and arm SI were significantly larger in IG ($12.2\pm 10.0\%$, range $-3.9-31.8\%$ and $10.1\pm 11.4\%$, range $-3.6\%-39.4\%$) compared to CG ($-0.2\pm 9.7\%$, range $-13.4-23.5\%$ and $-5.9\pm 16.2\%$, range -58.3 to 22.6%). Significant associations between leg and total ΔSI and all subscales of ΔCRF were observed for pooled data of IG and CG only ($r=-0.308$ to -0.394 , $p<0.05$). No statistical differences in ΔSI were observed when IG was divided into low- and high responders based on the median of each subscale of ΔCRF .

This study indicated that the strength training-induced changes in muscle strength and CRF are highly individual in cancer survivors undergoing chemotherapy. Moreover, changes in CRF may not necessarily be associated with changes in muscle strength. Future studies should assess the multifactorial origins of improved CRF in cancer survivors undergoing concomitant exercise training.

Novel Resistance Training Methods: Blood Flow Restriction and Hypoxia

Author: Brendan Scott

This presentation will explain what blood flow restriction is, its mechanisms of action, and how it can be implemented to enhance resistance training and rehabilitation. The recent use of systemic hypoxia during resistance exercise will then be discussed, and the potential limitations and benefits of this novel training method highlighted.

The Effects of Heavy-sled Sprint Training on Acceleration Capabilities in Female Rugby Sevens Athletes: A Pilot Study

Author: [Francesco S. Sella](#)

Co-authors: D. Travis McMaster, Brad Mayo, Kim Hbert-Losier, Nicholas D. Gill, C. Martyn Beaven

INTRODUCTION: Well-developed acceleration abilities are critical for performance in rugby sevens. In this pilot study, we investigated the effects of heavy-sled sprint training on acceleration in female rugby sevens athletes.

METHODS: Eleven junior female rugby sevens athletes completed 3-weeks of resisted sprint training (5-30 m) with heavy sleds (30 to 85% of body mass). Acceleration performance and biomechanical outputs were computed pre- and post-intervention using the methods described by Samozino *et al.* (2016). Training-induced changes were calculated using effect size (ES) and magnitude-based inferences. Correlations (r) between changes in sprint performance and biomechanical outputs (pre-post changes, and at baseline) were calculated.

RESULTS: Small improvements in 5 m and 10 m times, and changes in mechanical effectiveness of force application (RF_{max}), maximum power output (P_{max}), and force-velocity slope (S_{FV}) were observed (ES = 0.36-0.40). Very large to almost perfect correlations were found between changes in 5 m and 10 m times with changes in P_{max} , theoretical maximal (horizontal) force (F_0), RF_{max} , rate of decrease in mechanical effectiveness (D_{RF}), and S_{FV} ($r = 0.85-0.96$). Changes in 5 m and 10m times were also very largely to almost perfectly correlated with initial individual profiles (S_{FV} , D_{RF} , F_0 , and P_{max}) ($r = 0.73-0.91$).

DISCUSSION: Heavy-sled sprint training was likely to improve 5 m and 10 m times, maximum power, and sprint biomechanics. Changes in P_{max} , F_0 , D_{RF} , RF_{max} , and S_{FV} explained over 72% of the variance associated with improvements in 5 m and 10 m times. Furthermore, retrospective analysis showed that the initial individual force-velocity profiles were associated with the magnitude of improvements in sprint characteristics.

TAKE HOME MESSAGE: Heavy-sled sprint training is likely to increase acceleration capabilities over short distances in female rugby sevens athletes. Changes in defined biomechanical outputs, and individual force-velocity profiles appear to be associated with these improvements.

Effects of weekly resistance training in university physical education class during snow season on muscle mass, strength and jump performance.

Author: Keisuke Shibata

Co-authors: Nobuyasu Tomabechei, Kazuki Takizawa, Taichi Yamaguchi, Masao Mizuno

[Background] It has been reported that exercise performance declines during winter season in areas with a large amount of snow.

[Aim] To investigate whether weekly resistance training in university physical education class during snow season improves muscle mass, strength and jump performance or not.

[Methods] 30 male students performed resistance training mainly back squat (BSQ) and bench press (BP) at 60 ~ 85 % 1 repetition maximum (1RM) during 6th to 14th week in university physical education class during snow season. Muscle mass, BSQ and BP 1RM, distance of standing long jump (SLJ) and standing 5 step jumps (S5SJ) were measured at 5th (Pre) and 15th (Post) week. Participants were divided into two groups and analyzed either those who performed training with classes only (PE, n = 17, 172.5 ± 5.7 cm, 63.1 ± 5.0 kg) or those who voluntarily performed training in addition to the classes (PE +, n = 13, 170.7 ± 7.0 cm, 66.0 ± 10.8 kg).

[Results] BP 1RM (PE, Pre: 51.2 ± 10.5 kg, Post: 57.9 ± 10.2 kg, PE+, Pre: 59.6 ± 18.1 kg, Post: 64.6 ± 17.7 kg,) and BSQ1RM (PE, Pre: 79.6 ± 18.6 kg, Post: 90.7 ± 16.5 kg, PE+, Pre: 86.3 ± 23.5 kg, Post: 96.0 ± 16.8 kg) significantly ($p < 0.01$) increased similarly in both groups. Muscle mass, SLJ and S5SJ did not increase in both groups.

[Conclusion] Although muscle strength increased, muscle mass and jump performance were not improved by weekly resistance training in university physical education class during snow season. Voluntarily additional training outside the class does not produce further effects.

Effects of A Weight-belt On Intra-abdominal Pressure During the Back-Squat Exercise

Author: Norihiro Shima

Co-authors: Hidetaka Sakamaki, Yuto Matsuda

Over the years, power-lifters have used a weight-belt to increase the stability of the spine. It is believed that the use of a weight-belt increases the intra-abdominal pressure (IAP) by aiding in the compression of the contents of the abdominal compartment. Studies have shown that IAP can reduce the compressive force acting on the lumbar spine, while the effect of a weight-belt on IAP has not been well examined during back squat. We expected that IAP during back squat on light to very heavy load would not differ between with and without a weight-belt, because changes in IAP could be related to the force output linearly. The purpose of this study was to examine the effect of weight-belts on IAP during different loads of the parallel back squat exercise. Eleven male college students tested the maximum weight (1RM) of the back squat as a preliminary experiment. Subsequently, subjects performed the squat with and without weight-belt at 90%, 80%, 60%, 40%, 20% of 1RM. Based on our previous studies, IAP was measured using a pressure transducer placed intra-rectally. The maximum IAP was obtained from maximum voluntary pressurizations during Valsalva maneuvers taken from a standing position. The force from both feet was measured by force platform. All parameters were collected and interfaced to a computer via an A/D converter. The maximum IAP was higher with weight-belt than without weight-belt ($p < 0.05$). Although increases in IAP and the force were observed from light to very heavy load, there is no difference between with and without weight-belt. In conclusion, weight-belt would not affect changes in IAP during back squat exercise and suggesting that the effects of a weight-belt are not by increases in IAP but by other mechanical supports.

Validity of A Novel Method to Estimate Jump Height Using A Smartphone Face Detection Function

Author: Yohei Shimokochi

Co-authors: Yukihiro Aoyagi, Miki Yoshioka, Eiji Watanabe, Takaaki Mishima

Accurately estimating athletes' jump heights is often necessary for evaluating their power output capacity during strength training. We developed a smartphone application to estimate jumping height using the iPhone face detection function, and this study aimed to test its validity. Four subjects participated in the study. Each stood on force plates with an iPhone 8 front-facing camera capturing the face. The iPhone recognized the moments when the center of the face moved up from the initial point during take-off and came back to the initial point during landing and calculated the jump heights from the jumping time (JH_{Face}). The jump heights were also calculated from the impulse (JH_{Impulse}) and jumping time (JH_{Time}) measured using the force plates. Each subject performed 10 countermovement jumps with different efforts to change their jump heights in a random manner. Simple linear regression analyses ($df = 40$) examined the associations between JH_{Face} and JH_{Impulse} or JH_{Time} . Separate repeated-measures analysis of variance (ANOVA) followed by a least significant difference post-hoc comparison examined the differences in jump heights estimated by different methods ($N = 40$). Linear regression analyses revealed that JH_{Impulse} and JH_{Time} predicted 90.8% and 93.0% of variance in JH_{Face} , respectively (both $p < 0.001$). Repeated-measures ANOVA and post-hoc tests showed that JH_{Face} (34.5 ± 7.3 cm) was significantly larger than JH_{Impulse} and JH_{Time} (29.4 ± 6.1 and 26.7 ± 7.6 cm, respectively; both $p < 0.01$); however, the significant difference between JH_{Face} and JH_{Impulse} or JH_{Time} disappeared after correcting JH_{Face} values using each regression equation (both $p > 0.99$). Jump height estimated using the face detection function of the iPhone seems valid if the value is corrected using the appropriate equation. Thus, a smartphone could be an easily accessible tool to regularly evaluate athletes' jump and/or power output capacities in their strength training progression.

Difference in knee joint alignment between Japanese and Australian university students who played soccer during adolescence

Author: Akitoshi Sogabe

Co-authors: Susumu Iwasaki, Kazunori Nosaka

Introduction: Knee joint malalignment is evaluated by frontal plane and classified to genu varum (bowlegs) and genu valgum (knock-knees). A previous study (Thijs et al. MSSE, 2012) reported that excessive engagement in high-impact sports during adolescent might develop genu varum. It is common in Japan that junior athletes play one sport, as opposed to Australian junior athletes who tend to play multiple sports in a year. This study tested the hypothesis that Japanese university students who played soccer as a main sport would demonstrate more genu varum than Australian university students who played more than two sports.

Methods: Australian (n=42, 21.8 ± 3.7 y) and Japanese (n=22, 18.1 ± 0.5 y) male university students who played soccer (>2 times/week) when they were 13-15 years old participated in this study. The distance between right and left intercondylars and calcaneums were measured by a caliper to calculate knee alignment index (KAI): intercondylar distance – calcaneum distance. Their sport participation history was asked by a questionnaire. Independent t-tests were performed to compare between groups for KAI and other measures.

Results: KAI of Australian students (-8.8 – 5.8, 0.41 ± 3.12 cm) was smaller (P=0.006) than that of Japanese students (-6.2 – 6.0, 2.72 ± 3.02 cm). Australian students reported significantly (P<0.001) higher number of sports played regularly during adolescent (1 – 4, 1.93 ± 1.06) than Japanese students (1 – 2, 1.04 ± 0.02).

Conclusion: These results showed greater occurrence of genu varum for Japanese than Australian students. It is possible that focusing on soccer only during adolescent resulted in developing genu varum. Since genu varum is a risk factor of osteoarthritis, Japanese students may develop more osteoarthritis than Australian students when they get older. It may be that a multi-sport season system is desirable for healthy sport practice in youth.

Relationship Between Maturation and Performance Measures in Youth Females

Author: Lesley Sommerfield

Co-authors: Craig Harrison, Chris Whatman

One goal of youth strength and conditioning coaches is to develop an athlete for the long-term. To that end, the relationship between strength, maturation, technical competency and performance measures should be understood. The purpose of this study was to determine the relationship between maturation, strength, back squat competency and athletic performance in youth females. One-hundred and five adolescent females (mean \pm SD; age = 14.0 ± 0.6 y; height = 162.6 ± 5.8 cm; mass = 57.3 ± 9.7 kg; maturity offset = 1.8 ± 0.5 y) were tested for strength (isometric mid-thigh pull), squat technique (back squat assessment [BSA]), speed (10 and 20m sprint) and counter-movement jump (CMJ) power and height. Pearson correlations and linear regressions were used to investigate the relationship between variables. Results demonstrated that maturity offset was weakly associated with strength ($r = 0.30$) and CMJ height ($r = -0.21$), moderately associated with CMJ power ($r = 0.36$) and strongly associated with right and left CMJ power ($r = 0.54$ and 0.53 , respectively). Relative strength was strongly associated with speed (10 m, $r = -0.59$; 20 m, $r = -0.55$) and moderately associated with jump height ($r = 0.31-0.42$) whereas absolute strength showed weak to strong associations with all variables ($r = 0.28-0.61$) except jump height ($r = 0.15-0.26$). The BSA was weakly to moderately associated with speed ($r = 0.41-0.43$) and jump height ($r = -0.26$ to -0.37). Relative strength was the strongest predictor for 10 and 20m sprint (adjusted $R^2 = 0.357$ and 0.308 , respectively) and jump height (adjusted $R^2 = 0.090-0.179$) whereas absolute strength was the strongest predictor for jump power (adjusted $R^2 = 0.298-0.367$). From these results, relative strength appears most important for developing general athletic performance and should be considered when creating a long-term training programme for post-pubertal females.

The Collagen V alpha1, Growth differentiation factor5 and Peroxisome Proliferator Activated Receptor Alpha gene relation to movement screen results and neuromuscular performance in adolescent athletes

Author: Petr Stastny

Co-authors: Michal Lehnert, Mark De Ste Croix

Introduction

The adolescent age is characterized by maturation, which causes changes in musculotendinous condition resulting in high increase of physical performance, but also increased risk of injury. The purpose of this study was to determine whether *COL5A1*, *PPARA* and *GDF5* genes are related to injury risk factors, determined from functional movement tests in adolescent athletes.

Methods

A total of 146 youth players (14.4 ± 0.2) from various team sports (basketball $n= 54$, soccer $n= 50$, handball $n= 32$) underwent a manual test for muscle function, maturity estimation, functional bend test (FBT), passive straight leg raise test (SLR), leg stiffness test, test of reactive strength index (RSI), leg stiffness test, and gene sampling for *COL5A1*, *PPARA* and *GDF5*.

Results

MANOVA analyses showed that *COL5A1* rs12722 CT heterozygotes had worse score in FBT ($p < 0.001$), worse score in SLR ($p=0.003$) and lower maturity offset ($p= .029$, only in females) than TT homozygotes; *COL5A1* rs11103544 CC homozygotes had higher maturity offset than TT and TC genotypes ($p= .05$). Male *GDF5* rs143383 GG homozygotes showed better score in SLR than AA and AG genotypes ($p= .003$), and AA and AG genotypes had greater RSI than GG homozygotes ($p= .016$). The *PPARA* rs4253778 CC homozygotes had greater RSI than GG and GC genotypes ($p= .004$).

Practical application

The CT genotype in *COL5A1* rs12722 is a possible predictor of decreased muscle function score in the posterior hip muscle chain. Therefore, *COL5A1* rs12722 CT heterozygotes should be involved in specific programs targeting hamstring and posterior hip muscle chain flexibility. Woman *COL5A1* rs12722 TT homozygosity and both gender *COL5A1* rs11103544 CC homozygosity might be a predictor of faster maturation, therefore their performance should not be overestimated in practice. *PPARA* rs4253778 CC homozygotes and *GDF5* rs143383 AG and AA genotypes have a good potential to develop strength, power and speed in training.

The effect of breathing strategies on sticking region during bench press

Author: Petr Stastny

Co-authors: Dominik Kolinger, Dusan Blazek, Petr Kubovy

Introduction and aim: During the training session, bench press (BP) competition or testing session, athletes and coaches are trying to overpass the sticking region (SR) by movement modifications such as specific breathing techniques to increase performance, training volume or exercise load. Because the SR has not been analyzed during different approaches to breathing techniques, the purpose of this study is to analyze whether different breathing techniques can influence the time and track characteristics of SR during 1RM and 4RM BP exercise.

Methods: 24 resistance trained men (age 23 ± 2.4 , height 181 ± 5.2 , weight 85 ± 9.2) performed in randomized order 1 repetition maximum (1RM) and 4RM trials of bench press under five different breathing conditions using: traditional Va Isalva maneuver (VM), reverse breathing (REVB), hold-breath technique (HB), lung packing before hold-breath (PAC) and VM during elevated lower limb flat BP (FBP). 3D kinematics of the bar has been recorded by Qualisys system (Qualisys AB, Göteborg, Sweden), where the bar track and velocity has been recorded to describe the concentric phase of movement and SR in detail.

Results: The ANOVA showed that relative lifted load (load/ body mass, kg) differ ($p < 0.001$) only between REVB ($1.14 \pm 0.17 \text{ kg kg}^{-1}$) and all other breathing techniques (FBP $1.25 \pm 0.2 \text{ kg kg}^{-1}$; VM $1.24 \pm 0.19 \text{ kg kg}^{-1}$; HB $1.24 \pm 0.22 \text{ kg kg}^{-1}$; PAC $1.23 \pm 0.2 \text{ kg kg}^{-1}$). The VM showed shorter time of concentric phase ($p = 0.05$), time of SR ($p = 0.04$) than all other techniques during 1RM. The VM and HB techniques showed shorter track of SR ($p = 0.01$) than all other techniques during 1RM. REVB resulted in longest concentric track and longest pre-sticking region ($p < 0.001$).

Practical application: The VM is the most effective breathing technique to overpass the SR during successful lifts, which has shortest lifting time, shortest SR time and short SR track. Thus, VM should be used for all 1RM lifting.

Muscle Plasticity with Aging, Disuse and Rehabilitation Effects of Strength Training

Author: Charlotte Suetta

Co-authors:

The age-related loss of skeletal muscle mass (sarcopenia) is considered central to the development of metabolic, physiologic, and functional impairments and disability and is closely linked to an increased risk of falls, morbidity and mortality. Consequently, untreated sarcopenia not only is seriously affecting the single individual but also places a significant burden on the healthcare system and represent an important current and future public health issue. Depending on the population studied, the prevalence of sarcopenia is ranging from 10-30% (~70 yrs) within the general community to 50% in geriatric patients referred to a rehabilitation program after an acute hospital admission. Despite the high prevalence, the underlying causes of sarcopenia are yet not fully elucidated but are thought to be multifactorial and include increased levels of systemic pro-inflammatory cytokines, decreased number of spinal motor units, decrease in endogenous anabolic hormones and reduced myogenic stem cell function. Furthermore, physical inactivity, chronic diseases, immobilisation and hospitalisation are factors all known to play an important role in the development of sarcopenia.

Despite many efforts to develop a pharmacological treatment to counteract muscle atrophy, physical exercise is by far the most effective factor to combat skeletal muscle loss and myocellular atrophy in young, healthy elderly as well as frail patients. There is solid evidence for strength training to induce muscle hypertrophy as well as to evoke positive neuromuscular and functional adaptations. However, not all patients are able to perform progressive heavy resistance training and, in those circumstances, alternative training modalities should be introduced.

Hematological Status and Risk of Runners Anemia in Middle-aged Marathon Runners

Author: Kiichi SUGIYAMA

Co-authors: Aiko KOBAYASHI

Endurance training for marathon race has been associated with reduced hemoglobin (Hb) levels and low iron stores. Inadequate iron status may impair Hb and red blood cell production, causing anemia and impairing physical performance. These adverse effects of iron deficiency are well recognized in competitive marathon runner, however there are few data in recreational, middle-aged marathon runners. The purpose of this study is to clarify the iron status in these marathon runners and to examine the changes of hematologic values after marathon race.

The participants (ages 45.5 ± 6.5 yrs) included 113 male and female middle-aged marathon runners. All these subjects who had an expected finishing time within the official time limit of 5 hours were eligible. Blood samples were obtained for standard analysis to examine hematologic indices before and after Hokkaido Marathon race. As anemia state indicators (10 items), serum iron (Fe), red blood cell (RBC), white blood cell (WBC), Hb, hematocrit (Ht), mean corpuscular volume (MCV), mean corpuscular Hb (MCH), mean corpuscular Hb concentration, (MCHC), platelet (PLT), Ferritin (Fer) were determined. These values were assessed and categorized into 4 groups, according to high, normal, sub-normal, and low levels of the amount.

As a result, the erythrocytes' indices (MVC, MCH, MCHC) and iron status (Fe, Hb) were significantly lower in female runners. Thus, their iron status tends to be poor due to menstrual bleeding and hormonal in-balance, which tend to be resulted in "Female runner's anemia". In terms of age, only RBC value was significantly lower in older runners. Additionally, in spite of the significant increase of WBC after marathon race, the other hematologic values did not show significant differences. It should be suggested that recreational, middle-aged female runners may have higher dietary needs for iron to overcome their anemia without iron supplementation.

Relationship between load and power output of a great triple jumper during the back squat

Author: Yuki Suzuki

Co-authors:

Developing muscular power output is important component of athletic training programs for many athletes. The purpose of this study was to describe the relationship between load and power output of a great triple jumper during the back squat.

One male athlete (Triple Jumper; He is ranked around top 3 in Japan, 2018. Personal best record is 16.53m.) volunteered in this study. The subject age, height and mass were 24 years, 1.73m, 70kg, respectively. Maximum strength about the back squat (1RM: 1 repetition maximum) was 250kg that was measured before this study. Subject performed 0, 20, 40, 60, 80, and 100% of 1RM back squat using a plate-loaded Olympic Barbell. Each attempt was recorded using one video camera (120fps). Variables, i.e., vertical barbell position, vertical barbell velocity, vertical body center of gravity (CG) position, CG velocity, raise time, mechanical energy (ME), average power, peak power, segment angle and joint angle were calculated.

The results are summarized as follows: 1. As the load increased from 0-100% of 1RM, the back squat took a raise time. Therefore, as load increased from 0-100% of 1RM, vertical barbell velocity became slower. 2. Barbell of average power and peak power increased from 0-80% of 1RM. Maximal barbell of average power and peak power occurred at 80% of 1RM. 3. COG of average power and peak power decreased from 0-100% of 1RM. Maximal COG of average power and peak power occurred at 0% of 1RM (only body mass). 4. Net average power increased from 0-80% of 1RM. Maximal net average power occurred at 80% of 1RM. These result suggest that a great triple jumper should do 80% of 1 RM back squat if the athlete needs maximal power back squat training.

Specificity of resistance and impact training for maintaining bone in healthy and patient populations

Author: Dennis Taaffe

Co-authors:

Maintaining bone health in healthy and patient populations is critical for the prevention of osteoporosis and osteoporotic-related fracture. To this end, exercise is recognised as a modifiable lifestyle variable that can not only strengthen the musculoskeletal system, but also reduce the risk of falls and subsequent fracture, thereby prolonging independence and quality of life. However, questions remain in regard to the most suitable exercise mode or modes, as well as dosage, for an osteogenic effect. The importance of skeletal loading is readily apparent in extreme cases of skeletal disuse as occurs as a result of bed rest or spinal cord injury. Conversely, the beneficial effect of appropriate mechanical loading is readily apparent in athletes such as tennis players when comparing the playing and non-playing arms, in those exposed to high-impact activities such as in gymnastics, or those subjected to repeated muscle pull on the skeleton as occurs in weight lifters. Results from these cross-sectional athlete studies, early exercise trials in pre- and post-menopausal women, and from animal studies have shown that bone adaptive responses to mechanical stimuli are regulated by a number of loading factors which include that loads should be dynamic not static, should be of a high-magnitude, be applied rapidly, be usual or diverse in nature given that bone cells accommodate to customary loading, with rest periods between repeated bouts for an enhanced osteogenic effect. To this end, exercise trials have shown that low-impact customary activities such as walking have little if any effect on maintaining or enhancing bone health at the clinically important sites of the hip and spine. Conversely, progressive high-intensity resistance training has been shown to be beneficial as has moderate-to-high impact exercise that incorporates activities such as jumping, bounding, hopping and drop jumping, and it is their combination which is recommended to preserve and enhance bone health in healthy populations in order to not only prevent but manage osteoporosis. These exercise modes have also been recently trialled in prostate cancer and breast cancer patients who are subject to an accelerated rate of bone loss as a result of treatment and have shown efficacy in preserving bone health.

Women and concurrent strength and endurance training: Influence of hormones and hormonal contraceptives

Author: Ritva Taipale

Combined strength and endurance training (CSE) have many benefits when the training variables including mode, volume, and intensity are properly balanced. When not in balance, suboptimal adaptations or even “interference” may occur (4,12). Combined training can significantly improve, strength and rate of force production while improving endurance performance in terms of movement economy and/or speed. Additional improvements in body composition may also occur. While the benefits of CSE appear to apply to both men and women, there are markedly fewer studies examining CSE in women of reproductive age than in men. Studies including women rarely take into consideration or report hormonal contraceptive use and menstrual cycle phase. The purpose of this presentation is to review the literature on CSE in healthy post-pubertal pre-menopausal women and to discuss some of the physiological challenges that women face that should be considered in future scientific research and practical application regarding sport and exercise in women.

The menstrual cycle is a natural biological phenomenon for women that indicates potential fertility. While the way in which the menstrual cycle affects women is highly individual, the literature indicates that levels of strength, metabolism, inflammation, body temperature, and injury risk fluctuate concomitant with hormonal fluctuations. For example, in normally menstruating women, strength levels appear to be higher in the follicular phase than in the luteal phase (8) and strength training periodized with higher loads during the mid-to late follicular phase (and lower loads during the luteal phase) induces greater increases in S than traditionally periodized training (11, 13). Greater fat oxidation and excess post-exercise oxygen consumption (EPOC) has been observed during the luteal phase (6). An additional area of interest is how hormonal contraceptives (HC) may affect training responses and adaptations. Hormonal contraceptives suppress the endogenous production of estrogen and progesterone to prevent ovulation (9), which often results in increased concentrations of sex hormone binding globulin, increased morning cortisol secretion (1) and elevated chronic low-grade inflammation (2). Research about the effects of HC on CSE is extremely limited, but current findings indicate only small differences in adaptations to CSE between HC users and non-users (5,7).

A deficiency in understanding of effective training and lifestyle interventions for neuromuscular and cardiorespiratory fitness, body composition, and even performance in women still exists (3,10). Thus,

further investigation of the effects of menstrual cycle phase and HC use on CSE are needed to ensure that further research and exercise prescription, particularly in athletic women, is optimized.

Monitoring countermovement jump height and its mechanical parameters using a force plate in Wushu athletes

Author: Erik Tan

Co-authors: Kazunori Nosaka

Introduction: Countermovement jump (CMJ) is often used to assess lower leg strength and power of athletes. When CMJ is performed on a force plate, not only jump height but also several kinetic variables can be obtained to provide useful information for training program design and athletes' monitoring. It has been reported that peak concentric velocity and force positively correlated with jump height. However, less is known about CMJ variables for "Wushu" athletes who generally have high jumping ability. The present study investigated the changes in jump height and kinetic variables of CMJ over 4 weeks for Wushu athletes.

Methods: Thirteen male and seven female national level Wushu athletes (age: 20.2 ± 4.1 y, body mass: 58.7 ± 7.0 kg, height: 163.5 ± 6.9 cm) performed three countermovement jumps on a portable force plate, and this was reassessed four weeks later. Using the ballistic measurement software, peak concentric velocity (CON-Velocity), peak eccentric velocity (ECC-Velocity), peak concentric force (CON-Force) and peak concentric power (CON-Power) were also obtained for the best jump height trial. Correlations among the variables were analysed by Pearson's product moment, and the test-retest reliability of the measures taken 4 weeks apart was calculated. Since nine athletes showed more than 2-cm increase in the jump height, they were placed in Group A, and others were placed in Group B (less than 2-cm jump height increase). Changes in CON-Velocity, ECC-Velocity, CON-Force and CON-Power over 4 weeks were compared between the groups by t-tests.

Results: CMJ height was highly ($P < 0.01$) correlated with CON-Velocity ($r = 0.985$), CON-Power ($r = 0.851$), ECC-Velocity ($r = 0.529$) and CON-Force ($r = 0.693$). When comparing the groups, significant differences ($P < 0.05$) were observed for CON-Velocity and CON-Power, but not for ECC-Velocity and CON-Force.

Conclusion: These results showed that CON-Velocity was best correlated with the jump height. This suggests that training to improve velocity would be beneficial for these athletes.

Central Fatigue: Failure of The Nervous System During Exercise

Author: Janet Taylor

Central fatigue can be defined as a progressive exercise-related decrease in the ability of the nervous system to drive muscles maximally. Multiple mechanisms involving changes in the spinal cord and brain, and sensory feedback from the fatigued muscles underlie this failure of the nervous system during fatiguing exercise. For submaximal contractions, voluntary drive can often be increased to overcome central deficits but then the same task requires more effort. For maximal contractions, central fatigue results in reduced force output from the muscle. In some circumstances, it can account for more than half of the fatigue-related reduction of maximal force. Thus, failure of the nervous system is an important contributor to the decreased strength that occurs with muscle fatigue.

Single-leg Neuromuscular Function of Elite Athletes Prior To Returning to Sports After Lower-limb Injuries

Author: Joerg Teichmann

Co-authors: Wee Kian Yeo, Han Wei Lem, Dietmar Schmidtbleicher, [Erik Tan](#)

Introduction: A recent review suggested that the muscle function tests for injured athletes that are commonly used are not demanding enough or not sensitive enough to identify differences between injured and non-injured limbs. In this regard, few studies have examined the neuromuscular function of the injured athletes using single-leg tests. As such, the purpose of this study was to assess the single-leg strength and power function of injured elite athletes prior to returning to sports.

Methods: 16 elite athletes with lower limb injury who attended the Sports Medicine and Rehabilitation Clinic at the National Sports Institute of Malaysia from 2017 to 2018 were recruited to participate in this study. Upon completion of their rehabilitation program, and prior to returning to sports, the athletes performed the isometric single-leg press strength test and single-leg drop jump test from a 24cm platform. Another 34 non-injured elite athletes were recruited as control and went through similar tests. The mean of the absolute differences in strength and drop jump power measures between the injured vs. the non-injured leg were compared against that of the right vs. left leg of the control group.

Results: The absolute differences in mean force and jump height (from the 24cm single-leg drop jump test) between the 2 legs of the injured athletes were significantly higher than that of the non-injured athletes ($P=0.002$ and $P=0.006$ respectively). However, the absolute differences in single-leg rate of force development, contact time, reactive strength index and isometric single-leg press strength between the 2 legs of both groups of subjects were not significantly different.

Conclusions: Our findings indicate that the 24cm single-leg drop jump test may serve as a sensitive qualifying assessment for elite athletes prior to returning to sport after lower limb injuries.

Training Female Athletes: Special Considerations for Optimizing Performance and Avoiding Injury

Author: Travis Triplett

While it is generally accepted that man and women can perform similar resistance training programs with regard to program variables (sets, reps, rest, relative load, etc.), there are several physical aspects that may need special attention when designing a training regimen. Practitioners should be aware of the basic anatomical and physiological sex differences, as well as general menstrual cycle function and how it may impact training and performance. Conditions such as the Female Athlete Triad or Pregnancy present unique challenges and require adjustments to programming strategies. Common sites of injury in female athletes, such as the ACL, must be addressed, and there are many psychosocial factors that can affect the success of coach-athlete interactions and resulting training adaptive ability and performance. Each of these concepts will be briefly discussed with recommendations on how the practitioner can best use the information.

The Effects of A 12 Week Exercise Intervention on Physical Function and Psycho-social Wellness of Breast Cancer Survivors in Hong Kong

Author: Michael Tse

Co-authors: Glen Joe, Wendy Lam, Dora Lau, Helena Lo, Kevin Tang, Robert Newton

Breast Cancer is the third leading cause of cancer related death for women in Hong Kong. Exercise has demonstrated efficacy in minimizing treatment toxicities and improving quality of life (QoL). The aim of this pilot was to evaluate the effectiveness of supervised resistance and aerobic training on the psychological and physical wellbeing of Chinese breast cancer survivors and compare and contrast the effects of exercising in two settings. 38 breast cancer survivors were assigned to supervised gym-based (n=19) or center-based (n=19) exercise training for 12 weeks. Exercising in gym-based setting was conducted with use of standard fitness room equipment; while center-based setting was held in an activity room equipped with light weights and resistance bands. Patients were assessed for general and cancer-specific QoL, fatigue, pain, sleep quality, anxiety and depression, and other psychological wellness outcomes at baseline and 12 weeks, along with physical parameters. Both exercise interventions demonstrated significant improvement in cancer-specific QoL (FACT-B). Between-groups analysis indicated gym-based group reporting less fatigue than the centre-based group ($p < .05$). Both exercise settings demonstrated capacity to improve treatment-related loss of QoL. In terms of strength, both groups showed significant improvement in chest press, seated row and leg press. Shoulder range of motion of the surgery-side arm showed significant improvements in both groups, with the centre-based group demonstrating greater absolute changes compared to the gym-based group. As for body composition, the centre-based group showed greater fat mass loss, but less lean mass gain than the gym-based group. This study suggested moderate-to-high intensity exercise training was tolerable in local breast cancer survivors. This study also shows that patients may receive similar training effects when exercising in a cancer center-based exercise environment with less equipment, to training which is carried out in a gym-based setting with more expensive equipment and greater exercise choice.

RPE during assisted jumping

Author: James Tufano

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Introduction: Although ratings of perceived exertion (RPE) are used during resistance training, no research has investigated the use of RPE during assisted training. Therefore, we sought to determine whether RPE differs across multiple assistance levels during assisted jumping using two different assistance set-ups.

Methods: 18 active males (24.8 ± 3.0 yr; 178.8 ± 7.8 cm; 77.8 ± 7.8 kg) performed assisted jumping 1) where subjects physically held on to resistance bands that were attached to a transverse bar overhead as is often done in the field (_{FIELD}), and 2) where subjects were attached to long elastic bands via a body harness similar to many laboratory set-ups (_{LAB}). In each condition, subjects performed 5 sets of 5 countermovement jumps, and each set was performed with either bodyweight (BW), 10%, 20%, 30%, or 40% of bodyweight assistance. The order of each visit was counter-balanced, and the order of jumps within each visit was quasi-randomized. After the 5th jump in each set, subjects reported their RPE (0-10 OMNI resistance training scale). Effect sizes (Cohen's d) and a 2(condition) x 5(bodyweight) repeated measures ANOVA with an LSD follow-up test determined whether RPE was different across assistance levels, between conditions, or both.

Results: There was no assistance*set-up interaction ($p=0.06$) or main effect for set-up ($p=0.73$). There was a main effect for assistance ($p=0.03$), with RPE being greater at BW and 10% compared to 30% and 40% assistance ($p<0.05$). Effect sizes indicate that there were no effects across assistance levels in _{FIELD}, but there were moderate-to-large effects in _{LAB}, indicating a lower RPE during 30% and 40% compared to the BW, 10%, and 20% assistance conditions.

Conclusion: Assistance levels of 10-20% are likely perceived to be similar to bodyweight countermovement jumps. However, assistance levels of 30-40% may result in different RPE depending on the set-up used.

Resisted Sprint Training in Adolescents: The Effectiveness of Backward Versus Forward Sled Towing on Speed, Power and Stretch-shorten Cycle Measures in Youth Athletes.

Author: [Aaron Uthoff](#)

Co-authors: John Cronin, Paul Winwood, Jon Oliver, Craig Harrison

Resisted sprinting (RS) is a popular training method used to enhance sprinting performance in youth. However, to date research has only identified the effects of forward RS (FRS) on sprinting performance. We aimed to examine the effects of FRS and backward RS (BRS) and compare these to a traditional physical education curriculum (CON). One-hundred and fifteen adolescent males (age: 14.3 ± 0.49 y; height: 168.9 ± 8.9 cm; body mass [BM]: 58.3 ± 11.1 kg; maturity: 0.53 ± 0.92 y from peak height velocity) were matched for maturity and allocated to either a FRS (n = 34), BRS (n = 46), or CON (n = 35) group. Training groups towed progressively overloaded sleds (20-55% BM) 2 d/wk for 8-weeks. Pre and post-testing data were collected for 10-m sprint, vertical stiffness (k_{vert}), and countermovement jump (CMJ) performance. Alpha of $p \leq 0.05$ was used. All performance variables significantly improved following BRS (-2.4 - 26.3%; ES = 0.25 - 0.92), whereas FRS was found to significantly enhance CMJ (6.8%; ES = 0.45) and k_{vert} (19.3%; ES = 0.78), and CON performance remained significantly unaffected for any variable. Significant improvements were identified in the BRS compared to the CON for CMJ (ES = 0.61) and k_{vert} (ES = 0.94) while the FRS improved k_{vert} relative to the CON (ES = 0.69). Training effects for BRS and FRS did not significantly differ for any performance variable. The probabilities of improving performance following BRS, FRS and CON were 73%, 56% and 65% for 10-m sprint, 80%, 81% and 61% for k_{vert} and 75%, 79% and 55% for CMJ, respectively. Performing BRS appears to be a beneficial method for improving speed, power, and stretch-shorten cycle function in adolescent athletes. Regardless of direction, RS results in stiffer and more powerful lower limb capabilities compared to traditional physical education curriculum.

COMPARISON OF STEP-BY-STEP KINEMATICS AND MUSCLE ACTIVATION OF 30 M SPRINTS WITH 0-40 % BODY WEIGHT OF ACTIVE RESISTANCE IN SPRINTERS.

Author: Roland van den Tillaar

Not much is known about the acute effects of different resistances upon kinematics and muscle activation per step during resisted sprints. Therefore, the aim was to compare these step-by-step parameters when performing resisted 30m sprints in experienced sprinters.

Fourteen male sprinters (age 27 ± 6 years, body mass 76.6 ± 8.8 kg, height 1.80 ± 0.07 m, 100m: 10.81 ± 0.45 s) performed 30m sprints with un-resisted, and with resistance induced by dynaSpeed (Ergotest Innovation A.S., Porsgrunn, Norway), which gave an active pulling load of 10-40 % of body weight (BW): four different resistances. Kinematics were recorded during each attempt using a laser gun in combination with an infrared contact mat of 35m. Maximal angular velocity of ankle, knee and hip joint were measured with IMUs attached to these segments. EMG of ten muscle was also measured for each step during each sprint.

30m times increased with resp. 16, 31, 51 and 77% from 3.946 ± 0.277 (unresisted) to 6.994 ± 0.846 s (40% BW resistance). These increases were caused by lower maximal velocity reached earlier in the 30m sprints. The lower maximal velocity was a result of shorter step length, flight time and longer contact times. These changes were accompanied with lower maximal knee and hip extension, and plantar flexion with increasing resistance. Furthermore, maximal plantar flexion and knee extension increases from 0 to around 18 m in the 30m sprints. Rectus femoris and vastus lateralis activation increased with increasing resistance, while semitendinosis and biceps femoris activity decreased. It seems that gastrocnemius and soleus activity first increase until 20% BW. Thereafter it decreases with higher resistances again. Within the 30m sprints, only biceps femoris and gastrocnemius increase their activity over distance.

It was concluded that kinematics were affected by increasing resistance and our results suggest that high resistance sprinting is most useful for training quadriceps and calf muscles, but not for hamstrings.

An Age-adapted Plyometric Exercise Program Improves Strength, Jump Performance and Functional Capacity in Older Men

Author: Evelien Van Roie

Co-authors: Christophe Delecluse, Stijn Van Driessche, Benedicte Vanwanseele, [Simon Walker](#)

Rapid force production declines at a greater rate than maximum strength or muscle mass during ageing, resulting in functional deterioration. Plyometric exercises, using an eccentric pre-stretch phase quickly followed by a concentric phase, have been used in athletes and might improve rapid force production and functional capacity in old age. This study examined the effects of an age-adapted plyometric exercise intervention on (rapid) force production and functional capacity in older men and compared it to traditional resistance exercise and a progressive walking program. Thirty-six older men (69.4 ± 4.0 years) were randomized to 12-weeks of plyometric exercises (PLYO, $N = 11$), traditional resistance training (RT, $N = 11$) or walking (WALK, $N = 14$). Leg press one-repetition maximum (1-RM), leg-extensor isometric maximum voluntary contraction (MVC) and rate of force development in the first 200 ms (RFD), counter-movement jump (CMJ) height on a sledge apparatus, stair ascent (SA) duration and 6-minute walk distance (6MWD) were evaluated pre- and post-intervention. 1-RM improved similarly in RT ($25.0 \pm 10.0\%$) and PLYO ($23.0 \pm 13.6\%$) and more than in WALK ($4.6 \pm 14.5\%$) ($p = 0.001$). CMJ height improved more in PLYO ($14.4 \pm 11.8\%$) than in RT ($4.6 \pm 7.0\%$, $p = 0.030$) and WALK ($8.7 \pm 16.0\%$, $p = 0.036$). Within-group analyses revealed that; MVC tended to improve in RT only ($p = 0.05$), SA improved in PLYO only ($p = 0.025$), 6MWD improved in all groups ($p < 0.05$), and RFD did not improve significantly in any group ($p > 0.05$). Plyometric exercises can simultaneously improve strength, jump performance and functional capacity in older men either to the same or greater extent than traditional resistance training. Potential differential effects on MVC, RFD and functional capacity between exercise interventions need to be investigated in larger study samples.

Return to Baseline of Mean and Peak Velocity are Better Indicators of Readiness to Train than Maximal Strength

Author: [Alexander Vernon](#)

Co-authors: Chris Joyce, Jason A. Weber, Harry G. Banyard

Purpose: This study investigated the return to baseline of movement velocity and maximal strength following a typical strength-oriented and power-oriented session in the full depth, free-weight back squat performed with maximal concentric velocity. **Methods:** Twelve strength-trained males completed a power-oriented session (3-sets of 6-repetitions @50% of a one-repetition maximum [1RM]) and a strength-oriented session (5-sets of 5-repetitions @80%1RM) in randomised order over two weeks. At 24, 48, 72 and 96-hours following the training session stimulus, 1RM sessions were completed with loads of 20%, 40%, 60%, 80%, 90% and 100%1RM lifted. Prior to the completion of the training sessions, individualised baseline load-velocity profiles were conducted based on the relative loads 20%, 40%, 60%, 80% and 90%1RM. Differences from baseline mean and peak velocity (MV, PV) for each relative load was compared against the same load at each time point. 1RM was also compared between baseline and each time point. **Results:** Following the strength session, there was no change in 1RM at any time points, however MV and PV decreased ($p < 0.05$) at 24-hours for relative loads of 40% (MV: -5%, PV: -5%), 60% (MV: -8%, PV: -7%), 80% (MV: -10%, PV: -10%) and 90%1RM (MV: -23%, PV: -12%). There was no change in MV or PV following the power session. **Conclusion:** Return to baseline of MV and PV did not coincide with the return to baseline of maximal strength. Measuring meaningful changes in velocity may be a more practical monitoring tool than a 1RM assessment to determine an individual's readiness to train.

Effect of joint angle and inter-stimulus interval on measurements of tensiomyography

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Co-authors: Christopher Latella, Ricardo N.O. Mesquita, Kazunori Nosaka, Janet L. Taylor

Introduction: Tensiomyography (TMG) is a non-invasive tool that can assess skeletal muscle contractile function. Despite its growing popularity in exercise and sports science, it is unclear whether muscle length and rest-interval duration influence TMG measurements. This study aimed to determine the influence of joint angle and inter-stimulus interval on the muscle contractile parameters measured via TMG.

Methods: Fifteen recreationally-trained participants (13M, 2F; 29.5 ± 7.4 y) volunteered for the study. Evoked contractions of the right biceps brachii muscle were used to quantify TMG responses at three elbow flexion angles (10, 45 and 90), and two inter-stimulus rest-intervals (10 and 20 s) in a randomised order on two separate days. A three-way repeated measures ANOVA tested for effects of joint angle, rest-interval and day (1 and 2) on delay time (T_d), contraction time (T_c), sustain time (T_s), relaxation time (T_r) and maximal displacement (D_m).

Results: No significant differences in the parameters were found between days or rest intervals, but they were different between angles. T_d was greater at 90 ($\sim 3.4\%$, $p = 0.024$) and 45 ($\sim 3.2\%$, $p = 0.005$) compared to 10 (23 ± 1.7 ms). T_s was smaller at 90 (179 ± 28.9 ms) compared to 45 ($\sim 9.6\%$, $p = 0.023$) and 10 ($\sim 14.3\%$; $p < 0.001$). D_m was greater at 90 (17 ± 3.2 mm) compared to 45 ($\sim 22.8\%$; $p = 0.001$) and 10 ($\sim 41.1\%$; $p < 0.001$). T_c and T_r did not differ between angles.

Conclusion: The lack of effect of rest-interval suggests no occurrence of muscle potentiation or fatigue. However, elbow joint angle had a significant effect on D_m , T_s and T_d with less displacement when the muscle was longer. Thus, lateral displacement of the biceps brachii muscle belly, evoked by a maximal twitch and recorded through TMG, is sensitive to the muscle's length-tension properties.

PLANTAR FLEXORS TORQUE AND RATE OF TORQUE DEVELOPMENT IN YOUNGER AND OLDER MEN

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Co-authors: Douglas Pinheiro, Lucas Campos Ugliara, Savio Alex, Valdinar Junior, Rodrigo Celes, James Tufano, Martim Bottaro

Background: Maximal torque production declines with age and contributes to physical dependence and mortality. However, rapid torque characteristics, such as the rate of torque development, may decline to a greater extent than maximal torque, which would be undesirable in the plantar flexors since they play an important role in gait and balance.

Purpose: The purpose of this study was to compare peak torque (PT) and rate of torque development (RTD) of the plantar flexors between older and younger men.

Methods: Thirty apparently healthy men (15 older: 70 ± 6 yr; 70 ± 13 kg and 15 younger: 27 ± 4 yr; 78 ± 9 kg) reported to the laboratory for two familiarization visits and one performance testing visit. Plantar flexors torque was measured using a dynamometer sampling at 2000 Hz (Biodex System 4). Participants performed four maximal isometric actions using the right limb with 30 sec of rest between attempts. PT and RTD from 0 to 50 ms (RTD₀₋₅₀), 100 to 200 ms (RTD₁₀₀₋₂₀₀), and peak RTD were extracted using custom Matlab software. All PT and RTD variables were also expressed relative to body mass. Independent sample t-tests were applied, with a 5% level of significance.

Results: All variables were less in older men ($p < 0.5$), except for relative RTD₀₋₅₀. Older men demonstrated 30.8% less PT and 21.6% less relative PT ($p < 0.05$); less absolute (23.5%; $p < 0.05$) but similar relative RTD₀₋₅₀ ($p = 0.24$); and less absolute and relative RTD_{peak} and RTD₁₀₀₋₂₀₀ (31.7-42.8%; $p < 0.05$) than younger men.

Conclusion: Lower plantar flexors PT and RTD in older men may contribute to limitations in gait and balance control. RTD seems to be particularly important since the differences between younger and older men were greater than differences in PT. However, it is important to highlight that differences tend to decrease when normalized to body mass.

Key words: rate of force development, aging, muscular fitness

Seasonal strength and power characteristics of elite rugby league athletes

Author: Jarrold Wade

Co-authors: Joel Fuller, Paul Devlin, Tim Doyle

Introduction: The current research examined the strength and power profiles of elite senior and junior development rugby league athletes across the course of a rugby league season.

Methods: 25 elite senior and 20 junior development rugby league athletes were assessed at three phases of a National Rugby League season. An isometric mid-thigh pull test and countermovement jump test, conducted on a portable force plate, were used to assess lower body strength and power, respectively. A two-way analysis of variance was used to investigate the effects of age and playing position on baseline lower body strength and power during the pre-season. A linear fixed-effects model was used to investigate the effects of age and playing position across season phases.

Results: Isometric mid-thigh pull peak force was greater for senior compared to junior players (ES = 0.88, $p < 0.05$). Countermovement jump peak power was greater for outside backs (ES = 1.12) and hit-up forwards (ES = 1.23) compared to adjustables ($p < 0.05$). Senior players increased strength (ES = 0.41) and power (ES = 0.40) at end-pre-season compared to mid-pre-season ($p < 0.05$) and maintained these increases in-season. Junior players did not increase in absolute strength and power between mid- and end-pre-season but increased in strength (ES = 1.05) and power (ES = 0.42) in-season ($p < 0.05$).

Conclusion: The strength and power of rugby league athletes differs between age groups and playing position. Improving lower body strength should be prioritised for junior rugby league athletes because it is the main difference from senior players. Strength and power development of senior players should be targeted during the pre-season because improvements were not evident in-season when match performance was prioritised. Junior players and improve strength and power in-season; therefore, training should seek to develop these attributes in-season as part of a long-term athletic development plan.

Hypoxic Resistance Exercise: How Does Training to Failure or Not Influence Acute Physiological Responses?

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Co-authors: Olivier Girard, Andrew M Jonson, Brendan R Scott

Performing hypoxic resistance exercise versus normoxic is thought to augment metabolic stress and muscle swelling, which may further increase muscle growth. However, the influence of different exercise structures on these acute responses is unknown. This study aimed to compare acute physiological responses to resistance exercise in hypoxia and normoxia when sets are performed to failure or not.

Ten males with 2-years lifting experience undertook 10-repetition maximum (10RM) testing for shoulder press and bench press exercises. On separate days, they completed four trials in a normobaric simulated altitude chamber [two hypoxic (13% O₂) and two normoxic (21% O₂)], with condition order randomised. For each environmental condition, session one comprised 3 sets to failure of each exercise (100%, 80%, and 60% 10RM), while session two involved the same volume load, but over 6 sets. Heart rate and arterial oxygen saturation were assessed after each set. Blood lactate concentration ([Bla⁻]) was measured at baseline and after the last set of each exercise. Arm circumference was assessed pre and post-trial. Data were analysed via RM-ANOVAs, with significance set at $p < 0.05$.

Higher heart rate were observed during failure sessions compared to non-failure regardless of environmental condition ($p \leq 0.001$). Arterial oxygen saturation was lower during hypoxic sessions compared to normoxic regardless of training stimulus ($p \leq 0.001$). Failure sessions resulted in higher [Bla⁻] than non-failure sessions ($p \leq 0.001$), and hypoxia caused greater [Bla⁻] during the non-failure trials ($p = 0.003$). Arm circumference increased after all sessions ($p \leq 0.001$) and was higher following the hypoxia failure trial compared with both non-failure sessions ($p \leq 0.024$).

In reference to non-failure, resistance exercise to failure increased acute physiological responses, regardless of environmental condition. Nevertheless, hypoxia increased the metabolic stress of non-failure exercise above the normoxic equivalent, and failure training in hypoxia caused the largest increase in AC. These data suggest that hypoxia can augment physiological demands during resistance exercise, but this predominantly occurs when sets are not taken to failure.

Effects of Resistance Training Frequency on Markers of Metabolic Syndrome and Low-grade Inflammation in Healthy Older Men and Women

Author: Simon Walker

Co-authors: Heikki Kyrölinen, Heikki Kainulainen, Johanna Ihalainen

Introduction: Even healthy older individuals are more likely to experience adverse changes in body composition (i.e. higher fat and lower muscle mass) due to reduced physical activity. This increases the likelihood of developing adverse metabolic conditions and low-grade inflammation. Currently, conflicting evidence exists regarding the potency of resistance training to combat markers of the metabolic syndrome and low-grade inflammation, which may be due to programming variables. Here, we examined the effects of training frequency on selected biomarkers in blood and total body composition.

Methods: Healthy, but non-exercising, 65–75-year-old men and women volunteered for the study and were randomized to one of four groups. The groups performed whole-body resistance training one- (EX1, n=24), two- (EX2, n=24), or three- (EX3, n=26) times-a-week, or acted as non-training control (CON, n=20). Following a 12h overnight fast, blood samples were collected from the antecubital vein before and after the 6-month intervention. Serum samples were analyzed for lipid and lipoprotein, glucose, insulin, glycated hemoglobin (HbA1c), interleukin-6 (IL-6), high-sensitivity C-reactive protein (hs-CRP), and adiponectin concentrations. Total body composition was assessed by dual-energy x-ray absorptiometry to determine total body fat, abdominal fat and lean mass.

Results: After 6 months, EX3 reduced total (-1.3kg) and abdominal (-0.1kg) fat mass ($P < 0.05$). The intervention did not alter lean mass in any group. LDL concentration decreased in EX3 ($P < 0.01$), while HDL increased in all training groups ($0.14\text{--}0.19\text{mmol}\cdot\text{L}^{-1}$, $P < 0.05$). Adiponectin decreased in all training groups ($-1.0\text{--}-1.2\ \mu\text{g}\cdot\text{mL}^{-1}$, $P < 0.05$). Baseline IL-6 ($r = -0.583$, $P < 0.001$), hs-CRP ($r = -0.471$, $P < 0.001$), and triglycerides ($r = -0.543$, $P < 0.001$) were negatively correlated with their intervention-induced changes.

Conclusions: A higher number of resistance training sessions per week is beneficial for reducing fat mass and improving lipid profile. Nevertheless, individuals with a higher baseline in triglycerides and inflammation markers derived greatest benefit from the resistance training intervention, regardless of how many times-a-weeks they trained.

Acute neuromuscular fatigue during velocity-based resistance loading in men versus women when enforcing set termination at 20% and 40% of velocity-loss

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Co-authors: Roosa Virtanen, Shashank Mane, Joonas Rissanen, Bea Bachero-Mena, Juan Gonzalez-Badillo, Keijo Hkkinen, Fernando Pareja-Blanco

Introduction: One emerging method to train athletes is to assign a specific lifting velocity rather than load. Using these methods, researchers have observed varying adaptations from assigning different levels of velocity-loss (ranging from 1040% of initial velocity) prior to terminating each set [1]. However, manifestations of neuromuscular fatigue during these types of training sessions is unknown.

Methods: Full-squat loadings (~70% 1-RM, ~0.74m·s⁻¹ concentric velocity, 5 sets, 3min rest) were performed by young men and women (1835y). Participants were instructed to perform sets until initial velocity reduced by 20% (11 men and 9 women) or 40% (10 men and 7 women). Maximum bilateral isometric leg press (MVC) and countermovement jump (CMJ) with EMG recordings, blood lactate, as well as resting 10-Hz (Db₁₀) and 100-Hz (Db₁₀₀) doublets, and interpolated twitch tests were performed pre-, post- and 24h post-loadings.

Results: Post-loadings, MVC and CMJ performances were significantly reduced but there were no significant differences between 20% and 40% velocity-loss. EMG amplitude during MVC and CMJ did not change following any loading in men or women. In men, Db₁₀₀ (~14.6% and ~18.3) and Db_{10:100} (~24.3 and ~26.5) reduced after both 20% and 40% velocity-loss, but only Db_{10:100} reduced in women after the loadings (~15.9 and ~22.6, respectively). No changes in voluntary activation level occurred. Post-loading blood lactate was similar between-sexes for each velocity-loss, with a significantly higher concentration after 40% loss (men: ~4.8 vs. ~9.1mmol·L⁻¹; women: ~3.2 vs ~7.9mmol·L⁻¹). All variables had returned to baseline at 24h post-loading, except MVC after 40% velocity-loss in both men (~4.9%) and women (~8.0%).

Conclusion: Peripheral neuromuscular fatigue was observed following both 20 and 40% velocity-loss loadings in men and women. Only Db_{10:100} responses differed between sexes, suggesting that women may be more resilient to high-frequency fatigue.

Relationship Between Leg Press Eccentric / Concentric Strength and Sprint and Change of Direction Performance In Elite Rugby 7s Players

Author: Jad Adrian Washif

Co-authors: Ahmad Zawawi Zakaria, Kazunori Nosaka

Introduction: Many studies have demonstrated a significant relationship between knee extensor strength and sprint as well as change of direction (COD) performance in athletes of different sports. However, no previous study has focused on leg press eccentric strength in relation to sprint and COD. This study examined the relationships among leg press eccentric and concentric strength, sprint, and COD performances in highly-trained Rugby 7s players.

Methods: Fourteen national male Rugby 7s players in Malaysia (22.5 ± 1.8 y, 82.7 ± 10.2 kg; 173.1 ± 6.1 cm) were tested for bilateral leg press eccentric and concentric one repetition maximum (1RM), 40-m sprint (10 m, 20 m, 40 m) time, repeated sprint ability (RSA: 20 m x 12) and T-test. Correlations between the variables were analysed by a Pearson product moment coefficient (r).

Results: Leg press concentric 1RM was 570 ± 39 kg (range: 503-624 kg) and its relative value to body mass was 5.0-8.0, and eccentric 1RM was 867 ± 45 kg (778- 930 kg; 7.5-11.9). Sprint time was 1.72 ± 0.07 (1.63-1.83) s for 10 m, 2.97 ± 0.12 (2.86-3.22) s for 20 m, and 5.35 ± 0.24 (5.17-6.11) s for 40 m. The time was 41.05 ± 1.82 (39.2-46.4) s for RSA, and 10.57 ± 0.54 (9.74-11.68) s for T-test. Pearson's r showed correlations ($P < 0.05$) between relative eccentric / concentric 1RM and 20 m ($r = -0.72/-0.73$), 40 m ($r = -0.73/-0.76$) sprint, as well as RSA ($r = -0.64/-0.59$). Significant correlations were also evident between absolute eccentric 1RM and 20 m ($r = -0.57$) and 40 m sprint ($r = -0.55$), and RSA ($r = -0.63$), but no significant ($P < 0.05$) correlations were found for these with the absolute concentric 1RM. The ratio between eccentric and concentric 1RM (1.41-1.63) showed a significant ($P < 0.05$) correlation with T-test ($r = -0.65$).

Conclusions: These results suggest the importance of developing lower body eccentric strength to improve sprint and COD performance in elite rugby 7s players

Effects of Submaximal and Supramaximal Leg Press Eccentric Training on Changes in Eccentric and Concentric One Repetition Maximum

Author: Ahmad Zawawi Zakaria

Co-authors: Jad Adrian Washif, Boon Hooi Lim, Kazunori Nosaka

Introduction: Superior effects of eccentric to concentric resistance training on muscle strength have been documented, but less is known about the eccentric resistance training effects on highly-trained athletes. The present study investigated the effects of submaximal (6 weeks) and supramaximal (3 weeks) progressive leg press eccentric training on changes in eccentric and concentric one repetition maximum (1RM) strength.

Methods: Sixteen rugby 7s players (19-25 y) who represented Malaysia for the 29th SEA Games performed submaximal eccentric training 3 times a week for 6 weeks in which the load increased from 75% to 100% of concentric 1RM (5% increase/week). This was followed by 6 weeks of normal training period without eccentric training, then supramaximal eccentric training 3 times a week in which the load increased from 110%, 120% to 130% of concentric 1RM over 3 weeks. Eccentric 1RM leg press (5 s) and concentric 1RM leg press were measured before the eccentric training (T1), 5 days after the 18th training session (T2), after 6 weeks of no eccentric training (before the supramaximal eccentric training) (T3), and 5 days after the last (27th) training session (T4).

Results: Eccentric 1RM changed ($P < 0.05$) from 680.6 ± 71.6 kg (T1) to 862.5 ± 45.5 kg (T2), 812.5 ± 65.8 kg (T3) and 989.4 ± 74.8 kg (T4). For these time points, concentric 1RM changed ($P < 0.05$) from 499.1 ± 49.8 kg to 571.9 ± 39.9 kg, 515.3 ± 44.7 kg and 597.7 ± 64.1 kg. Eccentric 1RM increased greater ($P < 0.05$) from T1 to T2 ($27.7 \pm 7.2\%$) than from T3 to T4 ($22.0 \pm 7.6\%$), and concentric 1RM increased $15.2 \pm 8.5\%$ and $16.1 \pm 8.7\%$, respectively. The magnitude of decrease from T2 to T3 was smaller ($P < 0.05$) for eccentric 1RM ($-5.8 \pm 6.2\%$) than concentric 1RM ($-9.8 \pm 6.1\%$).

Conclusion: These results showed that the 6-week submaximal training was more effective than the 3-week supramaximal training for increasing eccentric strength, which was well preserved for 6 weeks without eccentric training in trained athletes.

EFFECTS OF EURYCOMA LONGIFOLIA JACK SUPPLEMENTATION ON TESTOSTERONE AND MUSCLE DAMAGE MARKERS

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Introduction: Eurycoma longifolia Jack (EIJ) or Tongkat Ali is a herbal plant of Southeast Asian origin and has been used as the traditional medicine for many different purposes. One of its functions is to stimulate the production or action of androgen hormones, especially testosterone. However, its supplementation effects on athletes are largely unknown. This study examined a short-term effect of EIJ supplementation on muscle damage induced by eccentric leg press exercise performed by athletes.

Methods: Sixteen young (19-23y) well-trained rugby 7s players (1.73 ± 0.16 m, 85.0 ± 10.5 kg) were randomly placed into two groups; one with EIJ supplementation and the other with placebo (PLA) of four 100-mg tablets a day for each for seven days prior to performing a leg press eccentric exercise using a 300-kg load (5-s eccentric contraction with the load, and without the load for concentric contractions) to failure. Muscle functions (countermovement jump: CMJ, drop jump: DJ), muscle soreness assessed by visual analogue scale, plasma creatine kinase (CK) activity, and salivary hormones (testosterone, cortisol) were measured at 24 h before and 24, 48, 72, and 96 h after the exercise, and the changes were compared between the groups by two-factor mixed-design ANOVA.

Results: The number of eccentric contractions performed was similar between EIJ group (21 ± 6) and PLA group (21 ± 8). The testosterone level after the supplementation was not different ($P < 0.05$) between EIJ group (488 ± 313 nmol/L) and PLA group (505 ± 299 nmol/L). Significant ($P < 0.05$) changes in CMJ (largest change: -12.7%) and DJ (largest change: -13.9%), increases in muscle soreness (peak: 6.9 ± 0.7 mm) and plasma CK activity (peak: 739 ± 420 IU/L) were evident without significant ($p > 0.05$) differences between the groups.

Conclusions: These results showed no significant effects of EIJ supplementation on hormones, exercise performance, and muscle damage markers for the young athletes used in the present study.

Perceptual, Metabolic, And Neuromuscular Responses To 10, 20, And 30% Velocity Loss Thresholds During the Barbell Back-squat.

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Co-authors: Kevin Till, Harry Banyard, Shaun McLaren, Nicholas Dalton-Barron, Carlos Ramirez-Lopez, Ben Jones

Introduction: This study compared the effects of 10, 20, and 30% velocity loss (VL) thresholds on differential ratings of perceived exertion (dRPE), lactate, and countermovement jump height (CMJ) during, immediately post-, and 24 hours post-five sets of the barbell back-squat.

Methods: In a randomised-crossover design, 15 resistance-trained males completed five sets of the back-squat with an initial mean concentric velocity of $0.70 \pm 0.01 \text{ m} \cdot \text{s}^{-1}$ and a set termination threshold of either 10% ($0.63 \text{ m} \cdot \text{s}^{-1}$), 20% ($0.56 \text{ m} \cdot \text{s}^{-1}$), or 30% ($0.49 \text{ m} \cdot \text{s}^{-1}$) VL. External load was manipulated throughout each session to ensure the first repetition of sets 2-5 was $0.70 \pm 0.06 \text{ m} \cdot \text{s}^{-1}$. Participants provided fingertip lactate at the completion of each set, while CMJ was collected pre-, post-, and 24 hours post-exercise. dRPE for the legs and lungs was provided at the completion of the 5th set. Three minutes rest was provided between sets, while barbell velocity was assessed during exercise to guide set termination.

Results: Peak lactate responses in the 30% condition were *likely* (effect size ± 90 confidence interval: 1.45 ± 2.29) and *almost certainly* (4.56 ± 1.66) greater when compared to the 20% and 10%, respectively. In the 10, 20, and 30% conditions, CMJ height was reduced by 11.3% (± 2.4), 14.0% (± 3.3), and 20.0% (± 3.4), immediately post-exercise. Additionally, dRPE (mean (\pm SD)) of the legs and lungs were, 10%: 27 ± 12 and 20 ± 9 ; 20%: 53 ± 16 and 50 ± 17 ; and 30%: 65 ± 18 and 65 ± 17 . At 24 hours post-training, CMJ performance was, 10%: $+0.7\%$ (± 2.4); 20%: -0.6% (± 2.0); and 30%: -2.7% (± 2.7).

Conclusion: Different VL thresholds during the back-squat cause varying perceptual, metabolic, and neuromuscular responses. The use of 30% VL thresholds can cause substantially greater metabolic responses and potentially attenuate neuromuscular function at 24 hours post-training. Alternatively, a 10% VL can mitigate perceived exertion and changes in metabolic responses. These findings should be considered during the planning of velocity-based resistance training programmes.

The Relationship Between Strength Characteristics and Performance of Elite Female Malaysian Badminton Players Across an International Season

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INTRODUCTION: This study highlights the strength characteristics of elite female Malaysian badminton players. It looks to identify the relationship between strength training adherence, estimated maximal lower body strength and world rankings. The study also aimed to analyse the impact of a potentially hectic international competition schedule on sub-maximal lower body strength.

METHODS: Ten (age 24.2 ± 4.3) elite female badminton players were tested via Back Squat (BS) and Trap Bar Deadlift (TBDL) lower body strength (LBS) estimated one repetition maximum (1RM), over the course of a forty-six-week period. Relative LBS (1RM/BW), number of completed strength sessions and international tournaments were monitored. LBS deficit 1-week post tournament (%), LBS change over the season (%) and player's world rankings were also tracked.

RESULTS: BS and TBDL LBS were estimated at $2.1 \text{ 1RM/BW} (\pm 0.6)$ and $1.9 \text{ 1RM/BW} (\pm 0.5)$ respectively over the season. Athletes averaged $62 (\pm 11)$ strength exposures and participated in $13 (\pm 7)$ international tournaments during this period. Mean LBS deficit after one week of competition was $3\% (\pm 4\%)$, whilst a 23.7% and 26.3% improvement in BS and TBDL LBS was observed over the forty-six weeks respectively. Mean world ranking was 137 pre-trial and 50 post-trial.

DISCUSSION: The logistics associated with preparing elite level athletes for multiple international competitions can potentially inhibit physical development. This study showed that athletes who trained more and competed less displayed continual improvements in LBS compared to those who competed more regularly. Frequency of strength training and selective tournament participation led to an overall improvement in world ranking over the course of a forty-six-week period. A significant drop in LBS was seen in athletes that travelled and competed in back to back tournaments.

PRACTICAL APPLICATIONS: Technical coaches must prioritise major competition across the international season and recognise the benefits of physical preparation blocks within the macrocycle. Strength and conditioning professionals should look to continually build on physicality year on year, achieving a better starting point each season which comes with frequency of LBS training. During an international badminton season athletes should train throughout the competition period to prevent any significant drop in physical qualities.

The Importance of Strength and Power on Key Performance Indicators in Elite Youth Soccer

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The purpose of this investigation was to examine the importance of strength and power in relation to key performance indicators (KPI's) within competitive soccer match play. This was achieved through using an experimental approach where fifteen subjects were recruited from a professional soccer club's scholarship squad during the 2013/14 season. Following anthropometric measures, power and strength were assessed across a range of tests which included the squat jump (SJ), countermovement jump (CMJ), 20 metre (m) sprint and arrowhead change of direction test. A predicted 1-repetition maximum (RM) was also obtained for strength by performing a 3RM test for both the back squat and bench press and a total score of athleticism (TSA) was provided by summing z-scores for all fitness tests together, providing one complete score for athleticism. Performance analysis data was collected during 16 matches for the following KPIs: passing, shooting, dribbling, tackling and heading. Alongside this, data concerning player ball involvements (touches) was recorded. Results showed that there was a significant correlation ($p < 0.05$) between CMJ ($r = 0.80$), SJ ($r = 0.79$) and TSA ($r = 0.64$) in relation to heading success. Similarly, a significant correlation ($p < 0.05$) between predicted 1RM squat strength and tackle success ($r = 0.61$). These data support the notion that strength and power training are important to soccer performance, particularly when players are required to win duels of a physical nature. There were no other relationships found between the fitness data and the KPI's recorded during match play which may indicate that other aspects of player's development such as technical skill, cognitive function and sensory awareness are more important for soccer-specific performance.

Does The 30-kilometer Training Run Before Marathon Race Reduce Time? - Randomized Controlled Trial in Recreational Runners

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PURPOSE: Due to conventional view of prominent runners and coaches, Japanese recreational runners tend to believe that a 30-km run four weeks before marathon would reduce their time. The present study aims to clarify whether this long run before marathon reduces their time or not with a randomized controlled trial (RCT).

METHODS: This study was conducted under a protocol prepared on the basis of the CONSORT statement which is an international guideline for RCT. The subjects, 165 voluntary recreational runners who participated in either the Osaka marathon (2016), the Kyoto marathon (2017) or the Senshu marathon (2017), were randomly allocated strong intervention (SI) group (85 runners) or weak intervention (WI) group (80 runners). The same training schedule for eight weeks were provided except 30-km (SI) and 10-km (WI) run four weeks before the marathon. The achievement index of the time (marathon time/personal best in the past three years x 100) was compared with t-test between groups under ITT (intention-to-treat) and PPS (per protocol set) analyses. ITT analysis was carried out in such a manner that the allocation of the subjects remained random, PPS analysis was carried out on the subjects, excluding the dropouts from the intervened portion of the training.

RESULTS: The achievement index (95% CI) was 103.8(101.8-105.7) for SI and 102.6(100.8-104.4) for WI, respectively, and the difference (SI-WI) was 1.2 (-1.5 - 3.8) points ($p=0.382$ with t-test) in accordance with ITT. They were 102.3(99.9 - 104.7), 101.5(99.6 - 103.5), and 0.8 (-2.2 - 3.8) points ($p=0.605$ with t-test) in accordance with PPS, respectively. Similar results were obtained by three marathons, respectively.

CONCLUSION: This study showed the 30-kilometer training run four weeks before marathon race did not always reduce time, statistically. It suggests that many recreational runners in Japan should reconsider their practice before a marathon.

Braking ground reaction forces during 90 sidestep cut and leg muscle strength

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Introduction: Braking is an important factor for change of direction (COD), but previous studies have only focused on the plant and penultimate step (PEN). This study compared ground reaction forces (GRF) of two braking steps, the PEN and the step prior to PEN (PEN-1), the entry and exit velocity of the COD, and leg muscle strength measures (leg press and leg curl one-repetition maximum, isometric and isokinetic strength, and drop jump) between faster and slower participants for a 90° sidestep cut.

Methods: Twenty-two male recreational athletes performed a total of six cuts (three in each direction) over five force plates to measure GRF during deceleration. The plant leg that resulted in the participant's fastest COD was defined as the dominant leg (DL) and the slower side defined as the non-dominant leg (NDL). The faster 10 participants (DL: 0.19 ± 0.02 s, NDL: 0.22 ± 0.02 s) and the slower 10 participants (DL: 0.24 ± 0.02 s, NDL: 0.31 ± 0.04 s) were identified based on 1m–1m COD time and the dependent variables between the groups were compared using independent t-tests.

Results: The faster COD group showed greater change in braking impulse from PEN-1 to PEN (-0.50 ± 0.31 vs -0.20 ± 0.15 m·s⁻¹, $p = 0.027$) for DL, and greater isometric knee flexor torque (1.94 ± 0.25 vs 1.63 ± 0.26 Nm·kg⁻¹, $p = 0.005$), isometric extensor torque (3.37 ± 0.42 vs 3.17 ± 0.71 Nm·kg⁻¹, $p = 0.017$) and concentric isokinetic (90°·s⁻¹) knee extensor torque (3.02 ± 0.47 vs 2.47 ± 0.39 Nm·kg⁻¹, $p = 0.03$) for NDL.

Conclusion: These results indicate that mechanical factors influencing COD were different between DL and NDL, and greater braking between PEN-1 and PEN resulted in faster DL COD. Further study is required to extensively examine the strategies associated with various COD performance.

Effects of Hyperoxia During Repeated Maximal Hammer Throws on Performance and Recovery

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Introduction: Aerobic energy production plays crucial roles in repeated short-duration maximal efforts such as hammer throwing, and inhalation of high concentration oxygen has been postulated to potentially enhance power outputs and reduce fatigue (Mallette et al. Sports Med 2017). However, no previous study has examined the effects of hyperoxia intervention on power outputs and fatigue during repeated hammer throws. Thus, this study tested the hypothesis that a hyperoxia intervention during 10 repeated maximal hammer throws would increase hammer throw performance and enhance recovery between hammer throws in comparison to a placebo (normoxia) condition.

Methods: Five male athletes (20-28 y) who specialised in hammer throw received both normoxia (21% oxygen) and hyperoxia (97% oxygen inhalation) treatments in a randomised double-blind cross-over design separated by 7 days. Each athlete performed a hammer throw with maximal effort every 5 min for 10 repetitions with a 5-min of normoxia (placebo) or hyperoxia treatment between throws. Throw distance (TD), blood lactate (La) concentration, rating of perceived exertion (RPE), maximum heart rate (MHR) and heart rate recovery (HRR) were measured at baseline and immediately after each throw.

Results: Average TD of 10 throws was 50.0 ± 6.3 m for the placebo condition and 50.6 ± 6.1 m for the hyperoxic condition, without a difference between the conditions. TD did not significantly change over 10 throws for both conditions from the first (placebo: 47.7 ± 8.5 m, hyperoxia: 51.7 ± 5.1 m) to the last the last throw (49.2 ± 8.6 m, 50.4 ± 6.4 m). La, RPE and MHR changed ($P < 0.05$) over 10 throws, but no significant ($P > 0.05$) differences were evident for the changes between conditions.

Conclusion: These results did not support the hypothesis and suggest that the inhalation of high-concentration of oxygen was not effective for improving performance and recovery in repeated hammer throws.

