Neuromuscular Mechanisms Revisited

Neuromuscular adaptations to strength training revisited

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Strength and power performances are determined not only by the quantity and the quality of the involved muscle mass, but also by the extent to which the muscle mass may be activated by voluntary effort. Today, it is well known that strength and power training may cause changes within the nervous system that allow an individual to more fully activate prime movers in specific movements and to better coordinate the activation of different muscle groups. These changes, referred to as “neural adaptation”, may induce a greater force, even in the absence of adaptation within the muscles themselves. Furthermore, changes within the nervous system may also allow force to be developed more rapidly.

Several observations underscore a significant role for the nervous system in the assessment of strength: (1) a dissociation between the increase in muscle cross-sectional area and strength; (2) a disproportionate increase in EMG compared with muscle mass; (3) a greater increase in strength gain when assessed by voluntary contraction than by electrically-induced contraction; (4) a poor transfer of strength gains to improvements in motor performance. Despite the evidence that suggests a significant role for neural mechanisms in strength-training adaptations, it has been more difficult to identify the specific mechanisms responsible of these changes. However, more recent techniques that involve motor and reflex responses induced either by electrical or transcranial magnetic stimulation and single motor unit recording have been used to examine the nature of adaptations that occur in the nervous system following a training program. Today, it appears that training adaptations include subtle changes in the relative contributions of the descending drive, afferent feedback, spinal circuitry and motor neurone properties. The purpose of this talk is to review our current knowledge of the underlying neural mechanisms of adaptations associated with strength and power training in humans.

General and Sport-specific Applications of Warming-up

General and specific applications of warming-up in alpine ski racing

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Introduction: Alpine ski racing demands a multitude of technical skills and physical abilities with excellent leg/core strength/power as well as a high aerobic/anaerobic capacity. Measurements demonstrated the importance of a slow SSC [1] and eccentric muscle actions [2]. The individual start time in ski racing is often unpredictable due to unforeseen interruptions. Warm up occurs outside where temperatures normally range from 0 °C to −20°C.

Evidence based knowledge related to general warming-up strategies: A reduced resistance of muscle/joints, greater release of oxygen from haemoglobin/myoglobin, speeding of metabolic reactions and increased nerve conduction...
rate are attributed to warm up [3]. Decreased muscle temperature results in decreased sprint performance [4]. Active warm up including submaximal/maximal isometric as well as dynamic contractions may increase subsequent strength/power performance [5,6]. Burkett et al. [6] found significant benefits on vertical jump performance following a weighted jump warm up. Protocols using submaximal loads and explosive execution are recommended by Gourgoulis et al. [7]. Dynamic stretching methods are beneficial to support subsequent high-speed performance [9].

Warming-up strategies in ski racing: Athletes usually conduct warm up runs with free skiing and skiing through gates before inspecting the course. After a short break (often in a lodge) direct race preparation begins. A general warm up to keep or increase body temperature together with dynamic stretching should initiate the race preparation. A small mat on the snow will allow a core warm up. Explosive exercises must also be included, such as squats with strong elastic bands for the legs, arm/shoulder exercises (for the start) and jumps focussing on the fast concentric and the eccentric phase. Reactions are very important in racing, so drills to stimulate the nervous system should be incorporated here as well. In very cold situations warming pads and special clothes should be used to maintain muscle temperature.

References


Warming-up in soccer

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Warming-up in soccer has to integrate a wide variety of aspects due to the complex nature of this sports discipline. In this sense, a broad spectrum of movement patterns (i.e. sprinting, jumping, kicking, cutting etc.) from low- to high-intensity as well as the preparation of the respective aerobic and anaerobic pathways have to be considered.

Like in many other sports, the first part of warming-up should consist of low-intensity movements which enable the increase of core and muscle temperature, the optimization of nervous function and the preparation of the aerobic pathways [1]. To integrate as much different movement tasks as possible it is recommended to use in the first part not pure running. Instead running can be combined with kicking and stopping tasks as well as with multidirectional movement behaviour. The second part of the warming-up procedure has to integrate the preparation of the specific joint and muscle systems which are used primarily in soccer. This is realized by performing several active movement preparation techniques (also called dynamic stretching) which also help to improve speed-related preparation [2]. In addition, such a joint- and muscle-specific warm-up may adjust the force generation to the necessary ranges of motion in soccer-specific important muscle groups (i.e. the hip flexors, the adductors, the hamstrings and the quadriceps muscles). Finally, in the third part all relevant motoric tasks in all necessary ranges of intensity (thereby incorporating also the anaerobic pathways) and under semi-specific conditions of the game (i.e. standing-leg and kicking-leg-coordination in specific tasks, 5:5 with the typical time- and space pressure) have to be integrated. Finally, power activities to promote the mechanisms of posttetanic potentiation may be used in this phase (i.e. jumping activities).

An important goal of the warm-up in soccer is to optimize short-term performance (first minutes of a game) and long-term performance (the whole match). In this sense, a warm-up of sufficient duration and intensity is necessary
but too long duration and too much intensity can lead to performance decrements due to fatigue-related mechanisms. In this sense, the recovery period between end of warm-up and the beginning of the game is important to consider (Bishop 2003). In addition, a structured strategy how to warm-up the substitutes is an important aspect of optimizing team success in a game.

References


The Role of Prevention through Sport & Exercises

**Injury prevention research in Luxembourg**

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Nowadays, an increasing number of children and adolescents engage in high-level sports practice. Early specialization into a sports discipline is often associated with elevated practice volumes and high training intensities. As a result, these young athletes encounter an increased risk for sports injuries, with potential health consequences for the athlete and a considerable economical impact. Research into sports injury prevention in Luxembourg was initiated in 2006, with the foundation of a research unit within the research centre for health CRP-Santé. Ever since, pioneering work has been supported by the national organizations of sports medicine and sports physical therapy, as well as the Ministry of Sports. The model of Van Mechelen has been adopted as a general investigation approach: description of injury incidence, investigation of risk factors, implementation of prevention strategies and evaluation of the latter by long-term screenings. Preliminary results based on a retrospective analysis on 276 athletes have revealed an overall incidence of 1.2 injuries per 1000 hours of exposure. The injury risk in competition was 2.2 times greater than during training. The lower limb was most frequently involved (>50%), and one injury out of 6 was severe (>4 weeks of interruption). Team and racket sports were associated with a greater risk than individual sports (OR of 2.4 and 3.0, respectively). Emotional stress, physical fatigue and injury outside sports are significant risk factors that warrant further attention. Prospective follow-ups are currently being performed, in close collaboration with sports federations and the recently founded sports school in Luxembourg.

**An ounce of prevention?**

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At a time when there is of an abundance of medical meetings, journals and papers, some might argue that the last thing we need is yet another field of research. What would justify such an emphasis on a new and developing research field in medicine? First, it must ask important questions not answered by others. Second, the new research field should have the potential to create truly new knowledge, lead to new ways of thinking and lay the foundation for improved health for our patients. Third, research results from the new field should be publishable in respected
journals, recognized and cited by peers, presentable at high quality meetings and fundable on competitive grant review.

First, is injury prevention important? Epidemiological studies show that of injuries seen by a physician in Scandinavia, every sixth is sustained during sporting activity. Among children, every third hospital-treated injury is the result of sports participation. A research group within the English Football Association found that the overall risk to professional athletes is unacceptably high – approximately 1,000 times higher among professional football players than for high-risk industrial occupations.

The second issue relates to the potential for new ideas and improved health. When we started the Oslo Sports Trauma Research Center in May 2000, a PubMed search revealed that out of 10,691 papers on athletic injury, there were only 6 randomized controlled trials on sports injury prevention. However, a similar search of the literature now reveals that sports injury prevention research is emerging as a new field in medicine. While the number of papers on athletic injuries has increased by 26% over the last five years, clinical studies and RCTs related to sports injury prevention has doubled.

Sports participation is also important from a public health perspective. There is no longer any doubt that regular physical activity reduces the risk of premature mortality in general, and of coronary heart disease, hypertension, colon cancer, obesity, and diabetes mellitus in particular. The question is whether the health benefits of sports participation outweigh the risk of injury and long-term disability, especially in high-level athletes? Sarna et al. have studied the incidence of chronic disease and life expectancy of former male world-class athletes from Finland in endurance sports, power sports and team sports. The overall life expectancy was longer in the high-level athlete compared to a reference group (75.6 versus 69.9 years). The same group also showed that the rate of hospitalization was lower for endurance sports and power sports compared to the reference group. This resulted from a lower rate of hospital care for heart disease, respiratory disease and cancer. However, the athletes were more likely to have been hospitalized for musculoskeletal disorders. Thus, the evidence suggests that although sports participation is beneficial, injuries are a significant side effect. To promote physical activity effectively, we have to deal professionally with the health problems of the active patient. This does not only involve providing effective care for the injured patient, but also developing and promoting injury prevention measures actively.

Advances in Preventing Sports Injuries

Injury prevention in sports medicine

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Epidemiological studies show that of injuries seen by a physician in Scandinavia, every sixth is sustained during sporting activity. Among children, every third hospital-treated injury is the result of sports participation. A research group within the English Football Association found that the overall risk to professional athletes is unacceptably high – approximately 1,000 times higher among professional football players than for high-risk industrial occupations. Some injury types, such as serious knee injuries, are a particular cause of concern. The highest incidence of anterior cruciate ligament injuries is seen in 15- to 25-year old athletes in pivoting sports such as football, basketball and handball, and the incidence is 3-5 times higher among women than among men. ACL injury causes long-time absence from work and sports, and dramatically increases the risk of long-term sequelae – like abnormal joint dynamics and early onset of degenerative joint disease. Although a massive research effort is ongoing to develop better treatment methods, we still lack evidence to suggest that reconstructive surgery of either menisci or cruciate ligaments decreases the rate of post-traumatic osteoarthritis. After ten years, approximately half of the patients display signs of osteoarthritis. Thus, whereas developing improved treatment methods for injuries in general, and ACL injuries in particular remains an important goal, it may be even more important to prevent injuries. When we
started the Oslo Sports Trauma Research Center in May 2000, a PubMed search revealed that out of 10,691 papers on athletic injury, there were only 6 randomized controlled trials on sports injury prevention. However, a similar search of the literature now reveals that sports injury prevention research is emerging as a new field in medicine. While the number of papers on athletic injuries has increased by 26% over the last five years, clinical studies and RCTs related to sports injury prevention has doubled. Today’s presentation will highlight current strategies and examples of sports injury prevention research.

**Advances in preventing shoulder sports injuries**

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Verhagen et al. [1] found that shoulder injury caused the longest mean absence from sports participation (6.2 ± 9 weeks) in volleyball players. In baseball, acute shoulder injuries were twice as likely during games than during practices yet two third of preseason injuries were non contact in mechanism, suggesting overuse injuries [2]. Except for the suprascapular neuropathy, the real etiology of shoulder pain among overhead athlete remains relatively unknown. The proposed risk factors for shoulder pain among volleyball athletes have been classified as intrinsic (anatomy, biomechanics, glenohumeral internal rotation deficit, muscle strength imbalances, core stability, previous injury, scapular dyskinesis and gender) and extrinsic (training errors, level of competition, load and fatigue) [3]. Some of those factors should be modifiable by rehabilitation, alteration of the throwing technique or load of training reduction during preseason and season [4].

Injury prevention should be a primary goal of every medical staff, athletic trainer and coach. Van Mechelen et al. [5] proposed the following sequence sports injuries prevention: (1) to establish the incidence and severity of the injury problem, (2) to identify the risk factors and mechanisms of injuries, (3) to introduce a preventive program and, (4) to assess the effectiveness and cost effectiveness of the preventive action by repeating the first step.

To our knowledge, no specific studies on prevention have been published to give evidence based guidelines for implementing intervention on shoulder pain. To be efficient, a preventive approach should require consistent information to players and trainers and a supervision process during the preventive training. Obviously, the athlete’s compliance should also be evaluated.

**References**


**Advances in preventing sports injuries – Back Injuries**

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Back injuries represent a large proportion of sports-related injuries, at all level of practice and in a very wide range of disciplines. The incidence of low back pain, acute or chronic, in athletes varies from 1 to 30% and is related to sport type, gender, training intensity, training frequency, and technique. The impact of back problems on training
and competition, but also in a global health care perspective is significant. Moreover, back injuries or pain is stated to be a risk factor for other sports-related injuries. Prevention of back injuries is thus a major concern for coaches and medical staff.

Our presentation will first outline the types of injuries encountered and the primary risk factors of back injuries (such as flexibility, history of low back pain, lower extremity problems, factors related to equipment), and identify the incidence of traumatic and non-traumatic back lesions in various sports disciplines. We will thus be able to identify the disciplines for which prevention is of major importance.

Several publications have assessed the efficiency of back injury prevention programmes in sportsmen. We will review these studies in order to identify those programmes that have demonstrated a significant effect and those that have not or not yet. Specifically, the efficiency of core stabilisation exercise programmes is still a matter of debate, despite its broad use on the field.

Several institutions have proposed guidelines for back injury prevention in recreational and competitive sportsmen. We will review these guidelines in the light of evidence-based practice. Based on these data, a proposal of guidelines will be presented and discussed.

**Muscle-tendon-stretching: advances in preventing injuries**

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Although stretching is commonly performed by athletes within their training routine in order to enhance sport performance or to reduce sport-related injury risk, these benefits have been largely questioned (Shrier, 1999 & 2004).

Introduced in warming-up routines, an acute static or ballistic bout of stretching has been shown to have either no effect or a deleterious effect on maximal voluntary isometric torque (Kokkonen _et al._, 1998; Fowles _et al._, 2000; Nelson _et al._, 2001; Nelson & Kokkonen, 2001), jump height (Cornwell _et al._, 2002) and muscle power (Yamaguchi & Ishii, 2005). Yet, recent findings have shown significantly improved leg power during cycling as a result of static stretching (O’Connor _et al._, 2006). Leg extension power similarly benefited from dynamic pre-exercise stretching (Yamaguchi & Ishii, 2005). These contradictory results could at least partly be explained by performance specificity and different stretching protocol characteristics (duration, posture, method). They should be discussed within the framework of the acute effects of stretching on biomechanical properties of muscle tendon unit (MTU) (Morse _et al._, 2007).

Sport performance appeared to benefit from regular stretching, when contraction velocity and force, jump height, and sprint speed were investigated (Shrier, 2004). Whether performance increase was due to enhanced stretch-tolerance or to some change in MTU biomechanical properties is not clear. Indeed, contradictory results are published about the effect of chronic stretch-training on the biomechanical characteristics of the MTU (Magnusson, 1996; Kubo _et al._, 2002; Guissard & Duchateau, 2004; Mahieu _et al._, 2007).

Stretching benefits for injury prevention have been repeatedly assessed (Shrier, 1999; Pope _et al._, 2000; Herbert & Gabriel, 2002; Weldon & Hill, 2003; Thacker _et al._, 2004) without any clear conclusion. In a recent review, Woods _et al._ (2007) suggested that specifically MTU related injuries could be reduced by stretching intervention.
The Female Athlete

**Gender differences in muscular adaptation to strength training**

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Systematic strength training is of increasing importance for men and women as a preventative measure, in physiotherapy and in a wide variety of sports at all levels of performance. After several weeks of regular strength training muscle hypertrophy with enhanced muscle and myofibre cross sectional area as well as an increase in the percentage area of fast type II fibres can be observed. These typical morphological muscular adaptations have been well characterized in numerous studies with male subjects of different ages. There is no doubt that also the female skeletal muscle responds to strength training with the development of hypertrophy. However, when the hypertrophic muscular response to heavy resistance training was compared between men and women in some few studies, results were conflicting showing greater, similar or smaller relative increases in muscle volume or muscle cross sectional area in females. Myofibre cross sectional area is significantly larger in men compared with women for the two fast (IIA and IIX) and the slow fibre types and there is some evidence that also the strength-training-induced increase in myofibre cross sectional area is greater in men. While fibre type distribution and its response to strength training with a decrease in the percentage of type IIX fibres is similar in both genders, the relative area occupied by type IIA fibres and the strength-training-induced increase in this area seems to be larger in men.

Recent investigations into heavy resistance training have provided evidence that the resulting skeletal muscle hypertrophy is due to enhanced protein translation, increased expression of genes involved in anabolic mechanisms as well as satellite cell activation and proliferation to provide additional nuclei to the enlarging myofibres. Such anabolic effects are mediated via the interaction of testosterone with the androgen receptor (AR) which leads to the up-regulation of several muscle-specific transcripts and probably also to increased muscle availability of insulin-like growth factor 1 (IGF-1). Serum levels of testosterone can be acutely and chronically elevated after resistance training in both genders, however, there are only few studies which have investigated AR expression in human skeletal muscle. There is some controversy about the effects of oestrogen and progesterone on myofibrillar protein synthesis. It was shown that in rats, these female sex hormones inhibit muscle growth. However, to our knowledge, such results have not been confirmed in human skeletal muscle. Furthermore, there is no clear evidence that the efficacy of strength training and myofibrillar synthesis change with varying oestrogen and progesterone concentrations during the menstrual cycle. IGF-1, which is secreted by liver and skeletal muscle, plays a prominent role in mediating muscle hypertrophy in response to strength training. Significant increases in the mRNAs of IGF-1 and its splice variant MGF (mechano growth factor) have been observed in human muscle after concentric/eccentric strength training, the increase in MGFmRNA being significantly greater in young men compared with young women. Further gender differences have been reported for circulating IGF-1 and some IGF binding proteins. IGF-1 is not only involved in the enhancement in protein synthesis but also stimulates proliferation, differentiation and fusion of satellite cells. Increases in the relative proportion of satellite cells and myonuclear numbers have been observed after several weeks of regular strength training and it seems that the myonuclear addition can best be accomplished by young men. There is some evidence that satellite cell activation and differentiation is most effectively stimulated by myotrauma. Significantly lower increases in creatine kinase (CK) in women compared with men after controlled eccentric exercise indicate diminished myofibrillar lesions in women and, probably, a reduced stimulus for satellite cell activation and differentiation. On the other hand, it was shown that, at least in rats, oestrogen might augment the training-induced increase in activated and proliferated satellite cells in the exercised muscles via the oestrogen-receptor.

In summary, muscle hypertrophy and the increase in the percentage area of fast type II fibres in response to regular strength training seems to be greater in men compared with women. The gender differences cannot easily be explained by the different serum levels of sex hormones. However, as the complexity in the regulation of strength-training-induced net protein synthesis as well as in satellite cell activation, proliferation and differentiation is only partly understood there is only little knowledge about gender differences in the mediation of muscular adaptation to strength training.
The female athlete triad: Facts and remedies

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The “female athlete triad” is a syndrome which is connected to three inter-related disorders: (1) disordered eating, (2) menstrual disorders, (3) osteoporosis. It has been observed in artistic gymnasts, ballet dancers, adult elite athletes and even in high school athletes. These young adults and teenagers are at increased risks.

Some female school children and athletes do have classic eating disorder, mainly driven by a strong need to maintain a low body mass for performance. Nevertheless, the anorexia athlete should be distinguished from pathological anorexia and voluntary eating disorders. One has to make the difference between disordered eating as opposed to eating disorder. Moreover, most of these athletes are compulsively overexercising. Thus, these is a negative energy balance when comparing the physical activity level and the food energy intake.

Intensive exercise training may lead to primary amenorrhea with the first period appearing several years later than originally planned by normal growth. Additionally, menstrual disorders, which is controlled by the hypothalamus and pituitary glands, progress from a reduced luteal phase to oligomenorrhea and then to secondary amenorrhea (with no ovulation). Often, during the first follicular phase, there is a loss of oestrogen production. It appears that the pulsatile release of luteinising hormone is decreased as compared to sedentary women. On the contrary, higher level of growth hormone and cortisol are observed with lower level of insulin and leptin. These hormones are highly related to energy metabolism and the hormonal imbalance will act on the nutritional status of the athlete.

Together with a reduced oestrogen level, there will be a progressive osteoporosis which is defined as a reduced bone mineral density. Several studies have consistently observed lower bone mineral density in amenorrheic athletes while runner athletes with menstrual disruption do have intermediate bone density. Bone tissues respond normally to mechanical stress and, with adequate nutritional intake, will increase bone resorption. Osteoporosis and osteopenia are associated with decalcification.

Prevention is better than cure and the ultimate goal will be to enhance the nutritional status of the athlete (including calcium and vitamin D intake). Treatment may be reliant on oestrogen replacement.

Injury Prevention Workshop

Clinical examination of the shoulder at risk in the overhead athlete: Focus on injury prevention

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Overhead athletes often show sport-specific adaptations at shoulder level, predisposing them for injuries. It is important in injury prevention to identify these alterations in the early stages of shoulder pain. The purpose of this workshop is to provide an algorithm for clinical reasoning and to discuss specific shoulder tests to identify possible causes of impingement symptoms, one of the most frequently described functional shoulder problems in overhead athletes.
Basic and advanced version of an injury prevention program for amateur football players

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The training program, the “11” has been designed for amateur football players aimed to prevent the most common lower extremity injuries: sprains to the ankle and knee, and strains to the groin and thigh muscles. The 15 minutes basic version includes ten evidence-based exercises know from injury prevention and rehabilitation.

Based on experiences with the “11”, this version has been further developed to the “11+”, which is combining the key exercises from the “11” and the “PEP” program. The “11+” consists of additional exercises to provide variation and progression, as well as a new set of structured running exercises in the beginning and the final part of the program that make it better suited as a comprehensive warm-up program for training and matches.

Prevention of low back injuries in sports

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In sports, the prevalence of low back pain is high and is linked to several risk factors including the practice at a high level of a sport involving an important mechanical load on the lumbar structures (gymnastics, soccer, tennis, golf, rowing, ...), the young age of the sportsman, an improper specific gesture technique and an inappropriate inclusion of strength exercises with heavy loads in the training program.

The prevention and treatment of low back pain in athletes comprise an adjustment of sport technique and training program, stretching of specific muscular groups, application of manual decompressive techniques for the intervertebral disks and facet joints and, potentially, the (re)education of the spine stabilization system. In fact, subjects suffering from lumbar instability appear to belong to a particular subgroup with low back pain. Lumbar stabilization exercises are aimed at sensorimotor reprogrammation of spine stabilizer muscles intended to improve their motor control skill and delay of response.

Designing Strength and Conditioning Programmes in Sports and Disease

Relation between conditioning and technical training in high performance sports

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Introduction: It is generally accepted that changing sports technique is a difficult task. Technically, changing technique is to find new optimal solution for given elements. Other way would be to change characteristics of the elements. Therefore, it seems quite obvious that change of sports technique should first be reflected in proper change of neuro-muscular system.

Methods: Two examples will be presented showing the effects of strength training on technique and discussing mechanisms possible mechanisms behind.

Results: In precision throwing, strength training improved only the task that required substantial power while in low power task no effects were observed. In sprinting, stride length and stride frequency were related to ratio
between proximal and distal muscles of leg extension. Even more, changing this ratio will change sprinting technique correspondingly.

**Discussion:** Strength training had direct effect on sports technique. However, it seems that effects of conditioning were more pronounced in tasks where substantial power was required. Potential mechanisms may include reduced radiation of activity to adjacent cortex areas or stronger muscles properly located.

**Conclusion:** Conditioning should be considered as an integral part of technical training. For its successful integration one needs to understand the role of neuro-muscular system in specific movement and the methods to achieve specific adaptation. This knowledge should be included in a studying schedule of those dealing with technical training.

### Lessons from single fiber studies for exercise training

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Exercise training, immobilisation or ageing have a considerable impact on the structure and function of skeletal muscle. The fact that skeletal muscle is a very plastic tissue is underscored by its specific reactions to certain environmental stimuli. A well-known adaptation following exercise (de-) training is the modification of muscle fibre type, which can change from slow, oxidative and enduring type I fibres to fast and more fatigable type II fibres relying more heavily on anaerobic metabolism. Recent findings from the scientific literature have also highlighted the potential of biomechanical studies performed on chemically skinned single human fibres to reveal training-specific changes within a given fibre type. Based on this model, the very fine functional adaptations of the contractile apparatus to different training stimuli have been explored. Resistance training induces an increase in fibre cross-sectional area and fibre force. On the other hand, endurance training enhances maximal unloaded shortening velocity. High-intensity plyometric training has the potential to increase both fibre force and shortening velocity. While fibre peak power is enhanced by resistance and plyometric training, it decreases following endurance training. Detraining is associated with a decrease in fibre diameter and force, while maximal contraction velocity rises. The muscle fibres from elderly individuals react somewhat differently to these stimuli. The lessons learned from single fibre studies enhance our understanding of the changes induced by exercise training or rehabilitation regarding skeletal muscle contraction performance.

### Designing strength and conditioning programmes in COPD

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Pulmonary rehabilitation has shown to be an important part of the management of patients with chronic obstructive pulmonary disease (COPD). Exercise training is the cornerstone of a comprehensive multidisciplinary pulmonary rehabilitation in COPD and has been shown to improve health-related quality of life and exercise capacity. Nevertheless, not every COPD patient responds well on regular pulmonary rehabilitation. New adjuncts to conventional pulmonary rehabilitation programs to optimise its effects on health-related quality of life, exercise capacity, body composition and muscle function have to be considered. Therefore, a patient tailored approach is inevitable. Advantages and disadvantages of several exercise modalities of pulmonary rehabilitation will be outlined in detail: endurance training, interval training, resistance training and transcutaneous neuromuscular electrical stimulation.
Effects of resistance training during the chemotherapy of breast cancer patients

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Introduction: Cancer patients suffer not only because of illness and medical therapies but also due to lack of mobility [1]. Only limited experience exists regarding resistance training with cancer patients [2]. Part of this study was to examine the feasibility and effects of resistance training during the chemotherapy of breast cancer patients.

Methods: 10 patients undergoing (neo-)adjuvant chemotherapy took part in a controlled 12-week resistance training programme, exercising twice a week for 60 minutes with a 75% MVC. Isometric and isokinetic measurements were taken using the ISOMED 2000. The questionnaire EORTC QLQ-C30 was used to assess quality-of-life.

Results: The level of resistance of the patients was maintained and even increased. The affected arm showed a significant increase in the maximum resistance. Regarding the outward rotation of the shoulder significant improvements were found for effort and performance. The level of maximum resistance in the non-affected arm was maintained. Regarding the assessment of quality of life, as significant improvement could only be achieved in Fatigue.

Discussion: Positive effects of resistance training on the level of resistance of the arms of breast cancer patients were registered, which confirm the study by Courneya [2]. For the first time the growth of the level of resistance was documented separately for both arms. No signs of complication were registered. Further studies have to follow, as the validity of the results remains somewhat weakened due to the small number of participating patients.

Conclusion: The results speak for the feasibility of resistance training during the treatment of breast cancer patients undergoing chemotherapy, and even prove that the level of resistance and quality of life can be maintained and improved.

References

Designing strength and conditioning programmes in chronic heart failure

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Chronic heart failure (CHF) is characterized by exercise intolerance that is not only caused by altered cardiac function, but also by endothelial dysfunction and muscle atrophy. Exercise training in CHF has proven to decrease mortality and readmission to hospital and to increase exercise capacity and quality of life. The increases in exercise capacity have been mainly attributed to partial reversal of peripheral dysfunction. Lately, there is growing evidence that cardiac function can also be improved by exercise training.

The large number of exercise intervention studies in CHF patients is composed of aerobic endurance training. However, recently a small number of studies where combined strength and endurance training or exclusive strength was applied indicated that supplemental benefits could occur by adding resistive strength exercises.

The focus of the presentation will be on the differential effects of various training modalities in CHF patients and their role in the improvement in the patient’s symptoms, health status and quality of life.
EISCSA Workshop 1

Isokinetic strength measurement

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Knowledge of the maximum strength capacity is an essential basis to develop and control appropriate interventions in prevention and rehabilitation. Strength capacity and sensory motor control is especially important for functional joint stability. Under this assumption assessment of functional strength testing of the lower extremities has to be considered as suitable measures to quantify deficits in conditions with a high demand of stabilization.

To identify (strength and sensory motor) deficits in Athletes with functional ankle instability dynamometer controlled testing situations (e.g. isokinetic Legpress; Con-trex LP) could serve as measurement tools, varying different demands on sensory motor control of the lower limb. The announced workshop will emphasis on functional strength testing of the leg extension movement (isokinetic Legpress) in stable compared to different unstable ankle joint positioning in concentric and eccentric mode. The purpose of functional strength testing is therefore to evaluate a profile of the strength performance capacity in situation with and without sensory motor control.

Exercise evaluation via EMG-biofeedback training

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The workshop is concerned with effective strategies of Biofeedback-training in therapeutic concepts. One topic is the evaluation of therapeutic and training exercises with multichannel SEMG. This part analyses the neuromuscular activation of functional and machine-based training exercises. A second topic addresses the principles of a biofeedback-based therapy concept. This part focusses on the leading parameters and the strategies of integration in complex therapy.

Muscle power: Significance and limits of evaluation tools

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In the field of physical preparation and high-level sport, muscle power is often of great importance with respect to performance. In fact, according to the type of sport, it is essential to improve power adequately. Some sport disciplines require preferentially either strength-power, speed-power or maximal power (Miller, 1997). Although, the evaluation of the maximal strength is generally not a problem for the coach, the choice of the optimal load for specific muscle power training and its follow-up during training sessions is more difficult.

Due to recent technological progress several equipments are now available on the market for the evaluation of muscle power, but it remains rather difficult for the coach to select the appropriate one. Moreover, how to use it adequately during training and the discussion of the results often remains a problem.
The objective of our presentation is to document the main currently available equipments and to discuss their capabilities and limitations.

Return to Play following Sports Injuries

Muscle injuries

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Muscle injuries constitute one of the most frequent sports lesions. Prevention of muscle strain includes proper conditioning and warm-up, and as well good management of fatigue. However, most muscle strains occur in sports competition requiring velocity and force. The objective in the treatment of a muscle strain is to create the best mechanical and biological environment to allow rapid and complete healing and thereby prevent a re-tear. Treatment must start within minutes after the injury, following the algorithm known as PRICE (Protection, Rest, Ice, Compression, Elevation) to prevent further damage and limit hematoma formation. Protection is a crucial step for the first two to three days (crutches, or even immobilization) to prevent excessive scar formation and re-rupture at the injury site. In the coming years, the use of IGF-1 injection may improve and accelerate the healing process. After this protective phase which can extend up to five days in severe injuries, controlled isometric, isotonic and isokinetic contractions of the injured muscle group are performed with increasing intensity. At the same time one should begin general reconditioning of the athlete, either by activation of the upper extremity in the presence of a lesion of the lower extremity, or by activation of the contralateral limb. Reconditioning of the injured muscle group is mandatory. Gentle, progressive, and pain-free sports-specific re-programmation is rapidly begun. The criteria for time to return to sports include: (1) Ability to stretch the injured muscle as much as the contralateral healthy muscle; (2) Pain-free use of the injured muscle in sports-specific movements; and (3) Comparable strength between injured and healthy muscles. There is an obvious lack of evidence in determining these criteria and these guidelines are mostly empirical.

In patients with a true muscle rupture surgical re-insertion and repair should be considered, particularly with lesions in the proximal hamstrings or distal pectoralis major. The surgical management of these injuries permits a reduction in the length and degree of functional disability.

Numerous research studies concerning the use of growth factors and cytokines have shown promising results in improving muscle healing. It has been demonstrated that IGF-1, b-FGF, and HGF improve muscle regeneration, while anti-TGF-{\beta} agents (decorin, gamma-interferon) as well as an anti-fibrotic agent (suramin) decrease the development of fibrosis and favor muscle healing. Finally, genetically modified stem cell-based therapy holds great promise for the treatment of muscle strain.

The means to reduce the length of disability in athletes with muscle strains are the following: (1) Take them off the sports field; do not even permit them to play; (2) Apply the proper treatment immediately and PROTECT the injured muscle; (3) Start controlled motion and general reconditioning; (4) Recondition the injured muscle and rapidly begin sports-specific re-programmation; (5) Surgically re-insert and repair a muscle rupture (especially hamstrings proximally); and (6) Consider the use of hyperthermia which appears to be a promising technique to reduce the length of disability.
Ankle injuries and return to sports

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Ankle ligament injuries are still the most common sports-related injuries, in spite of the fact that researchers have introduced preventive programmes, which may have reduced the frequency of these injuries. It is also well known that most of the ankle injuries are related to the lateral ligaments, with either partial or – most often – total rupture. Such ligament damage is traditionally not considered to be of serious nature, neither in the medium nor the long term. However, it has become more obvious that several athletes suffer from sequels and, which is probably most important, concomitant injuries. Such injuries, like peroneal tendon dislocation, peroneal tendon rupture or injury to the syndesmosis increases the risk of surgical intervention and long delay until sports resumption. It is therefore of major importance to carefully evaluate the injured ankle. There is no such thing as a “simple ligament injury”.

In terms of return to sports, the healing time must be considered, and all the different phases of ligament healing must be born in mind. Accordingly, the ankle must be protected for a long time after a seemingly benign injury.

After a rupture to the lateral ankle ligaments, return to sports is often allowed – or even encouraged – after 7–10 days. However, this may lead to long-standing pain and possibly residual laxity, due to the fact that normal ligament healing is disturbed.

Three things are important when an ankle injury is evaluated, first of all to rule out a fracture, second to bear concomitant injuries in mind, for instance when healing takes more time than is considered normal and third to allow the ligaments to heal properly before sports resumption. The time may differ from one subject to another, and may be correlated with several issues, like previous injury, alignment and age.

Return to play after anterior cruciate ligament (ACL) surgery

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The decision when to return back to strenuous physical activity after ACL reconstruction is challenging and the criteria to be fulfilled to send an athlete back to sports in good physical condition with a minimal risk of re-injury after ACL surgery are not well defined yet. The evolution of the surgical techniques and the rehabilitation protocols over the last 2 decades has been such that patients can usually start with level I sporting activities between 2 to 4 months after surgery. At this moment high level evidence-based data are available showing that early weight-bearing, early mobilization of the operated knee, rehabilitation without braces and early closed kinetic chain exercises are safe with respect to graft healing and remodeling (Beynnon B 2002 & 2005).

Return to level II activities (pivoting sports) is usually considered in a time frame between 6 to 9 months after surgery. But at that moment the surgeons’ clinical criteria such as free range of motion, the presence or absence of pain and swelling as well as objective knee laxity measurements or even the use of scoring systems like the globally recognized IKDC score are not sufficient to evaluate the functional capacity to return to sport with criteria objectivating the patients’ coordinative, strength and endurance capacities. Furthermore, late-stage rehabilitation health-care coverage is often questionable. Other issues to be considered in this debate are psychosocial factors like the players’ excessive motivation or fear of re-injury; the often insufficient knowledge of the re-injury risk of the athlete, trainers and parents and the increased pressure from the athletes’ entourage.

The high incidence of re-injuries, the risk of developing secondary knee osteoarthritis and the necessity of monitoring the rehabilitation process are areas of major interest for athletes, clinicians and researchers. In high-level
pivot sports the risk of a re-tear of the ACL or an ACL injury of the contra lateral knee has been shown to be up to 21% (Myklebust & Bahr, 2004) and the rate of any revision surgery after ACL reconstruction (including cartilage and meniscus surgery) has been evaluated at 4.9 / 100 person-years (Dunn WR, 2004). Between 50 and 70% of the patients develop secondary knee osteoarthritis 10 years after ACL injury with and without ACL reconstruction (Myklebust & Bahr, 2005). Routine isokinetic muscle strength tests revealed quadriceps deficits of 19-44% and hamstring deficits up to 21% at 6 months after ACL surgery (Muellner T, 1998; Risberg MA, 1999; Wojtys EM, 2000; Henriksson M, 2002). Specific hop tests and later test batteries have been developed to assess the functional and coordinative capacity after ACL surgery (Risberg MA, 1994; Gustavsson A, 2006). As a complement of these test batteries, the concept of muscle fatigue has been introduced recently by Augustsson J and Karlsson J (2004), showing that under fatigue conditions only 1/3d of ACL reconstructed patients achieved normal values at 11 months after ACL reconstruction. The analysis of landing strategies after a drop-jump maneuver is another area of interest which demonstrated altered coordinative capacities of the operated leg up to 2 years after ACL-reconstruction (Decker MJ, 2002; Paterno MV, 2007).

These findings show that modern rehabilitation processes should be criteria or goal-based and not only time based. The monitoring of the end stages of rehabilitation and safe return to sport should include measurements of neuromuscular control, strength, power and lower extremity symmetry. Because of the high sensitivity of test batteries the clinician is recommended to use them in the decision-making process when deciding whether and when athletes can safely return to sports activities. The overall aim is to develop reliable and sensitive methods like isokinetic tests, single-leg hop tests, functional CKC tests, functional scores and kinematic 2D or 3D analysis. A major practical problem still remains regarding to time required for these evaluations, the cost for the health care system and the investment for the equipments.

Shoulder injuries

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Chronic shoulder pain is probably the most common upper extremity problem in recreational and competitive overhead athletes. Throwing athletes, athletes involved in racquet sports such as tennis, volleyball players and swimmers need full, unrestricted upper extremity function to optimally perform in their sport.

Internal impingement is a commonly described cause of shoulder pain in the overhead athlete, particularly the tennis player. Three shoulder dysfunctions, frequently correlated with internal impingement symptoms, need our attention in the rehabilitation strategy of internal impingement in the tennis player: 1) acquired glenohumeral anterior instability, 2) loss of internal rotation ROM, and 3) lack of retraction strength.

Based on recent literature, the following guidelines are proposed in the rehabilitation of the tennis player with internal impingement symptoms: 1) shoulder rehabilitation should be integrated into kinetic chain training, not only in the advanced phases of the athlete’s rehabilitation, but from the initial phases, 2) angular as well as translational mobilizations can be used in the treatment of acquired loss of glenohumeral internal rotation range of motion to stretch the posterior structures of the glenohumeral joint, and 3) in the rehabilitation of scapular dyskinesis, the therapist should focus on restoration of intramuscular trapezius muscle balance in the scapular exercises, with special attention to strength training of the retractors.
Ageing and Functional Performance

Decline in muscular function with ageing – from molecules to function

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In the elderly, skeletal muscle in association with disease development plays an important role in the physical function level in everyday life and future risk of morbidity and mortality. Altered intracellular metabolic capacity and enzyme activity of skeletal muscle due to sedentary lifestyle strongly influence the development of lifestyle associated diseases such as metabolic syndrome, obesity and type-2 diabetes. Furthermore, the loss of muscle mass per se and the development of sarcopenia, plus the preferential loss of fast contracting type II fibers and, thus, reduction in contraction velocity, are highly relevant to morbidity and mortality in the elderly. Low muscle mass is correlated with lower functional capacity and is also associated with a higher risk of falls and fractures, and from early mortality after hip fracture. Both content of contractile proteins in the individual muscle fibers and the number of muscle fibers decrease with age. The more dramatic loss in the fast type fiber content leads not only to weaker muscle contractions, but also to slower muscle contractions. After the age of 65 yrs the loss of muscle strength is around 1.5% per year, and the loss in muscle power declines even faster, up to 3.5% per year. The main questions are, to what extent can elderly persons counteract their skeletal muscle loss, and what roles do training and nutrition play. In master athletes of 70–80 years, it has been shown that life-long strength trained individuals have a similar muscle power to 20-year-old untrained healthy individuals; corresponding to a trained elderly person strength wise rejuvenated around 20–30 years. Training studies show that even in individuals over 80–90 years, a strength-training program will result in a 30–50% improvement in strength. Most importantly, however, is the fact that these studies also demonstrate an improvement in everyday functional abilities such as chair rising and stair climbing. Potential differences in regulation of muscle growth in the elderly compared to young individuals have not been fully outlined. Actors that have been debated in relation to aging and muscle growth in response to training are the reductions in endogenous testosterone level and growth hormone (GH) secretion with age. The somatopenia in elderly persons may be timewise coupled to sarcopenia, but studies in which growth hormone was supplemented to elderly men either isolated or in combination with strength training, showed that no further effect of strength training was obtained with GH supplementation, despite the fact that GH raised the circulation levels of insulin-like growth factor I to a level identical with that of young individuals. A further factor that has been discussed in relation to aging and skeletal muscle is the number and activity of satellite cells. In younger individuals satellite cells are not only active in the case of tissue injury and repair, but also play a physiological role in providing new myonuclei as the muscle fiber grows in relation to strength training. Recently it has been shown that elderly individuals – independent of sex – increase their number of satellite cells in response to physiological strength training. This indicates that this pathway for forming new myonuclei is maintained in the elderly. In conclusion, strength training in the elderly is beneficial, not only to healthy individuals, but also in patients groups characterized by an impaired muscle function. Furthermore, strength training in patients who have undergone operation is shown to be beneficial. Nutritional supplementation containing essential amino acids timed at immediately next to the training bout seem important to obtain full effect of muscle strength training in the elderly.

Muscle function and ageing

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Adequate maintenance of muscle mass throughout life is essential to preserve not only locomotion, but also metabolic and energy homeostasis. Muscle is the main organ for glucose uptake and contributes to ~25% basal
energy expenditure and even more during exercise. Aging is accompanied by a loss of skeletal muscle mass defined as sarcopenia, which represents a major cause of disability, loss of independence and frailty resulting in an increased risk of death. While the responsible mechanisms are not fully understood, sarcopenia is characterized by a loss of fibers and a reduction of cross-sectional area (CSA) of the remaining fibers, with fast-twitch fibers (FT) undergoing larger atrophy than slow twitch fibers (ST). Since FT are able to develop 5–6 times more power than ST, the functional deterioration of FT can severely limit dynamic movements, such as catching oneself to prevent fall. Sarcopenia is a consequence of old ages, but chronic illness, poor diet and physical inactivity definitely exacerbate it. As a result effective strategies that preserve the number and the quality of muscle fibers are of critical importance for independence and quality of life of elderly people. Resistance training has been used to successfully increase strength even in very old men (>80 y), but with only a minor influence on whole muscle CSA suggesting a neurological origin of the strength gain (Slivka et al., AJP 2008). Satellite cells are muscle stem cells capable of lifelong maintenance and repair of differentiated muscle cells. The decline in muscle adaptation to resistance training is partially explained by a decrease in regenerative capacity and a reduced availability of satellite cells with age. Recent discoveries have contributed to the understanding of sarcopenia by identifying signaling pathways (Notch and Smad) implicated in the decline of regenerative competence of muscle stem cells (Carlson et al., Nature, 2008).

The effects of long term Whole Body Vibration training in older individuals

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Whole Body Vibration: (WBV) training is a relatively recent type of exercise training which is strongly promoted in the health- and fitness sector. During WBV, exercises are performed on a platform that generates vertical sinusoidal vibrations, stimulating the muscle spindles and leading to reflexive muscle contractions [1,2]. In general, long term vibration training can be seen as an efficient alternative for conventional resistance training in young individuals [3]. Only a few studies have looked for the neuromuscular effect in older individuals, but the results are promising. Studies have shown that muscle strength gains after 6 and 12 months WBV training were similar to those induced by an equal number of fitness training sessions [4,5]. Recently, it has been shown that these strength improvements were not solely due to neural adaptations, but also to an increase in muscle mass [5], suggesting that WBV can have important clinical implications. WBV does not only improve muscle function, but because of its hypertrophic effect may potentially improve health outcome by reducing/reversing the age-related process of sarcopenia and its related disorders. Additionally, the positive effects of WBV training on postural control [6–8], functional performance [9, 10] and bone density [7] in elderly suggest a possible role of WBV in the prevention of falls and fall related fractures. Although a lot of positive results have been shown about the long term effect of WBV in older individuals, there is still a lack of knowledge about the safety concerns, optimal training characteristics, dose-response relationship of the vibration stimuli and about the effects on health in frail elderly.

References

EISCSA Workshop 2

Functional strength training

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The concept of functional strengthening is a more recent approach in the field of muscular conditioning. Within this concept the goal of training is to stimulate the muscles in the typical way muscles are activated in sports movements. Consequently, the focus of such a strategy is not only on optimisation of performance of the prime movers, like in the classical strength training approach, but also on the targeted activation of the stabilizer muscles.

In the first part of the workshop the concept of identifying basic movement patterns and the related postural behaviour in sports is presented. These basic movement patterns, in turn, are “one” important basis of exercise selection. The second aspect is to consider which muscles are important in force generation in the identified basic movement patterns. In this sense, a special focus is on the stabilizer muscle activity.

In the second part of the workshop, several “functional” exercises will be presented. Generally, in these exercises the athlete trains handling the body weight and/or segments in all planes of movement.