The Second European Isokinetic Society Congress

Neuromuscular Performance in Research and Clinical Applications

March 15 and 16, 2002

Crans Montana, Switzerland
**EIS Congress Program**

**MAIN HALL**

Friday, March 15th, 2002

**The eccentric contraction**  
*Chair: J.L. Croisier, P. Aagard*

13:00 Neural activation during maximal eccentric muscle contraction: effects of strength training  
*K1*  
P. Aagard, Denmark

13:30 EMGs and strength patterns of the quadriceps during isokinetic extension of the knee in different contraction mode  
*O17*  
P.M. Dugailly, D. Mouraux, N. Llamas, J. Duchateau, E. Brassinne, Belgium

13:45 Effect of short-time eccentric training on the eccentric performance of the quadriceps  
*O16*  
E. Brassinne, D. Mouraux, G. Lambert, J. Duchateau, Belgium

14:00 Isokinetic eccentric exercises in treating chronic tendinitis  
*O23*  
J.L. Croisier, B. Forthomme, M. Foidart-Dessalle, B. Godon, J.M. Crielaard, Belgium

14:15 Eccentric isokinetic strength training in stroke patients effects on motor function  
*O26*  
D. Moreaux, R. Delire, C. Suavage, C. Heyters, P.M. Dugailly, Belgium

14:30 Coffee break

15:00 **Opening Ceremonia**  
*Chair: D. Schmidbleicher*  
Music; Greetings [Local representants, EIS-President]; Music

15:30 **Congress lecture**  
*K2*  
*Chair: F. Mayer*  
Neuromuscular performance in research and clinical application  
A. Gollhafer, Germany

16:30 Coffee break

**EXHIBITION HALL**

**Scientific Poster Session**  
**Quality control in rehabilitation**  
*Chair: S. Brahn, L. Radlinger*

13:00 Peak torque/angle-curves in concentric isometric and eccentric mode for knee and ankle joints in healthy men  
*P1*  
T. Horstmann, P. Neumann, F. Mayer, H.C. Heitkamp, H.H. Dickhuth, Germany

The effect of an oscillating blade on trunk and upper extremity musculature  
*P17*  
T. Horstmann, P. Neumann, F. Mayer, H.C. Heitkamp, H.H. Dickhuth, Germany

A new way of active control of posture in apparatus based muscle testing exercise  
*P11*  
G. Berschin, H.M. Sommer, Germany

Influence of anesthesia on isokinetic muscle performance in patients with impingement syndrome  
*P21*  
B. Forthomme, J.L. Croisier, J.P. Huskin, F. Absil, F. Stroobants, J.M. Crielaard, Belgium

Contribution in the increase of the muscular force by mechanical stimulation  
*P8*  
T. Cherouali, L. Afilial, N. Manamanni, S. Moughamier, L. Angeloz, France

Differences between inverse dynamics and maximal isometric moments of force for the knee and ankle joints on elite sprinters  
*P33*  
A. Veloso, P. Armada da Silva, J. Abrantes, Portugal
**Children and elderly**  
*Chair: K. Häkkinen, Y. Henrotin*

17:00 Effects of strength training in elderly  
*K3* K. Häkkinen, Finland

17:30 The quality of motoric recuperation in schools of Romania  
*O31* M. Dragomir, I. Rinderu, A. Antoniale, Romania

17:45 The different stages in development of fundamental motoric skills in boys and girls  
*O32* C.A. Stroe, A. Antoniale, M. Barbu, L. Antoniale, Romania

18:00 Force production characteristics of trunk muscles in lumbar disc surgery patients  
*O18* A. Häkkinen, J. Ylinen, Finland

18:15 Isokinetic evaluation of hip muscles in patients with coxarthrosis  
*O25* Y. Henrotin, B. Ralet, J.E. Dubuc, J.L. Croissier, J.M. Crielaard, Belgium

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**The eccentric contraction & High-performance athletes**  
*Chair: S. Brahn, L. Radlinger*

17:00 Eccentric versus concentric isokinetic evaluation of trunk extensors in standing position  
*P14* P. Voisin, P. Bibré, M. Goethals, P. Masse, T. Weissland, J. Vanvelcenhuis, France

Influence of strength performance disorders on hamstring strain recurrence  
*P29* J.L. Croisier, B. Forthomme, M. Namurois, M. Vanderthommen, J.M. Crielaard, Belgium

The development of 1 repetition maximum (1 RM) depending on the training frequency during a hypertrophy training program with high performance athletes  
*P19* K. Wirth, D. Schmidtbleicher, Germany

Influence of physiotherapy and insoles on isokinetic peak torque of the ankle and EMG of lower leg muscles in runners with unilateral Achilles tendon complaints  
*P28* A. Hirschlümer, H. Baur, S. Grau, H.C. Heitkamp, H.H. Dickhuth, F. Mayer, Germany

Muscular endurance of the lower leg muscles in runners with unilateral Achilles tendon complaints  
*P15* H. Baur, A. Hirschlümer, S. Grau, T. Horstmann, H.H. Dickhuth, F. Mayer, Germany

Balance training in male and female judokas gain in strength  
*P27* H.C. Heitkamp, M. Fleck, F. Mayer, T. Horstmann, H.H. Dickhuth, Germany

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**High-performance athletes**  
*Chair: A. Belli, A. Schlumberger*

09:00 Strength training of athletes in rehabilitation  
*K4* A. Schlumberger, Germany

09:30 The effects of intensive volleyball practicing on the muscular balance of the rotator cuff of the shoulder  
*O9* C. Dupuis, C. Tourny-Chollet, N. Biette, F. Beuret-Blanquart, France

09:45 Strength profiles of the knee muscles linked to the playing position of soccer players  
*O2* N. Biette, S. Sangnier, C. Dupuis, C. Tourny-Chollet, France

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**Scientific Poster Session**  
*Chair: W. Laube, Y. Henrotin*

09:00 Peak torque/angle-curves in concentric isometric and eccentric mode for knee and ankle joints in healthy men  
*P1* T. Horstmann, P. Neumann, F. Mayer, H.C. Heitkamp, H.H. Dickhuth, Germany

The effect of an oscillating blade on trunk and upper extremity musculature  
*P30* J. Rieger, H.C. Heitkamp, F. Mayer, H.H. Dickhuth, Germany

A new way of active control of posture in apparatus based muscle testing exercise
10:00 Concentric and eccentric strength of trunk in athletes

O13 T. Weissland, P. Voisin, A. Tomaszewski, H. Delahaye, J. Vanvelcenhaver, France

10:15 Glycogen utilization and composition of skeletal muscle in elite junior alpine skiers

O7 M. Vogt, M. Wittwer, B. Schmitt, K. Jordan, H. Spring, H. Hoppeler, Switzerland

P11 G. Berschin, H.M. Sommer, Germany
Influence of anesthesia on isokinetic muscle performance in patients with impingement syndrome

P21 B. Forthomme, J.L. Croisier, J.P. Huskin, F. Assil, F. Stroobants, J.M. Crielaard, Belgium
Contribution in the increase of the muscular force by mechanical stimulation

P8 T. Cherouali, L. Afilial, N. Manamanni, S. Moughamier, L. Angeloz, France
Differences between inverse dynamics and maximal isometric moments of force for the knee and ankle joints on elite sprinters

P33 A. Veloso, P. Armada da Silva, J. Abrantes, Portugal

10:30 Coffee break

**EIS State-of-the-art Session: Training and testing in open vs. closed kinetic chain**
Moderation: F. Mayer

10:45 Introduction & Background

E1 A. Schlumberger

11:05 Poster presentations

E2 EIS Physiotherapists, Athletic Coaches, Scientists, Medical Doctors, Industry

11:15 Poster information

12:00 Guided Discussion

12:45 Summary

E3 A. Schlumberger

13:00 Lunch Break

**Quality control in rehabilitation**
Chair: D. Schmidbleicher, F. Mayer

14:00 Study of EMG activity of the hamstring during isokinetic movements of the knee

O24 E. Brassinne, D. Mouraux, M. Tits, P.M. Dugailly, Belgium

14:15 Efficacy of linear isokinetic versus dynamic auxotonic muscle training for the shoulder- a prospective, randomised controlled study in men

O5 J. Petermann, P. Klein, A. Behrens, L. Gotzen, M. Schierl, Germany

14:30 Isokinetic study of primary total knee arthroplasty

O10 Y. Andrianne, P. Remys, E. Brassine, D. Bernard, Belgium

14:45 Relationship between the health related to the quality of life and the isokinetic strength at wrist and knee

O6 N. Gusi, D. Forte, A. Ortega, Y. Garcia, C. Wilke, B. Schulte-Frey, Spain/Germany

15:00 Coffee break
Neuromuscular and neurological disorders
Chair: J. Duchateau, A. Gollhofer

15:30 Neuromuscular adaptations to reduced activity
   K5 J. Duchateau, Belgium
16:00 Proprioception and thus muscle strength
   measurement of the knee joint
   O12 H.M. Sommer, A. Hofmeier, G. Berschin,
   Germany
16:15 Isokinetic strength and gait parameters in mul-
   tiple sclerosis
   O3 P. Thoumie, E. Mevellec, France
16:30 Normal values of con- and eccentric peak
   torque, work and performance of modified pnf-
   patterns of the shoulder
   O4 M. Schierl, P. Klein, J. Petermann, L. Gotzen,
   Germany
16:45 Isokinetics as a tool to assess instantaneous pas-
   sive stiffness of spastic ankle joint
   O20 L. Dupont, G. Rabita, C. Pérot, A. Thevenon,
   G. Lensel-Corbail, J. Vanvelcenaheer, France

17:00 Closing remarks
   D. Schmidtbleicher

The eccentric contraction &
High-performance athletes
Chair: W. Laube, Y. Henrotin

15:30 Eccentric versus concentric isokinetic evaluation
   of trunk extensors in standing position
   P14 P. Voisin, P. Bibré, M. Goethals, P. Masse,
   T. Weissland, J. Vanvelcenaheer, France
   Influence of strength performance disorders on
   hamstring strain recurrence
   P29 J.L. Croisier, B. Forthomme, M. Namurois,
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   The development of 1 repetition maximum
   (1 RM) depending of the training frequency
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   P19 K. Wirth, D. Schmidtbleicher, Germany
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   netic peak torque of the ankle and EMG of
   lower leg muscles in runners with unilateral
   Achilles tendon complaints
   P28 A. Hirschmüller, H. Baur, S. Grau, H.C.
   Heitkamp, H.H. Dickhuth, F. Mayer, Germany
   Muscular endurance of the lower leg mus-
   cles in runners with unilateral Achilles tendon complaints
   P15 H. Baur, A. Hirschmüller, S. Grau, T.
   Horstmann, H.H. Dickuth, F. Mayer, Germany
   Balance training in male and female judokas
   gain in strength
   P27 H.C. Heitkamp, M. Fleck, F. Mayer,
   T. Horstmann, H.H. Dickuth, Germany

Oral presentations: Each presentation consists of 10 min. presentation and 5 min. of discussion.

Poster presentations: Each poster presentation has to be held twice (Friday and Saturday) to offer the opportunity for discussion to all participants. Each poster will be presented by the authors (2–3 min.) at the scheduled time. Additionally, one of the authors has to stay at the poster for discussion during the whole session.
Keynote Abstracts
Neuromuscular aspects of eccentric muscle contraction in vivo evaluated by use of isokinetic dynamometry

Per Aagaard
Team Danmark Testcenter, Sports Medicine Research Unit, Bispebjerg Hospital, and Dept. of Neurophysiology, Inst. of Medical Physiology, Panum Institute, University of Copenhagen, Copenhagen, Denmark

Isokinetic dynamometry is a highly useful tool to evaluate the mechanical and neuromuscular performance of human skeletal muscle during eccentric contraction in vivo. The use of isokinetic dynamometers not only enables a reproducible assessment of eccentric muscle force, but also allows to address the aspect of neural innervation during eccentric contraction in agonist and antagonist muscles.

Eccentric muscle strength is important for a number of reasons: high levels of eccentric muscle force are generated in maximal explosive stretch-shortening-cycle (SSC) movements, for example during maximal sprint running and jumping, in alpine skiing, karate and weight lifting. In fast movements, high eccentric strength of antagonist muscles allows for a rapid phase of limb deceleration, which increase the time available for acceleration, in turn increasing maximal movement speed. Resistance training may be used to increase the eccentric strength of antagonist muscle to achieve an enhanced capacity for muscular joint stabilization, potentially protecting ligaments and capsular structures [1,2].

When obtained in isolated muscle preparations, eccentric contraction force is substantially greater than that observed during isometric and concentric contraction. However, for intact human muscle a marked inhibition in maximal eccentric muscle strength can be found in untrained subjects, suggesting that the pattern of neural motor outflow is of particular importance for the expression of maximal eccentric muscle strength in vivo.

Motoneuron activation appears to be reduced during maximal voluntary eccentric muscle contraction in untrained subjects, suggesting the presence of a neural inhibitory mechanism [3–5]. Presumably, this neural mechanism serves to protect the integrity of the joints, as it may prevent excessive ligament/capsular stress forces and bone-on-bone forces. Whether the suppression in eccentric muscle strength is caused by a selective recruitment of fast type II muscle fibres remains unknown. Based on EMG recordings, a preferential recruitment of fast type II motor units and de-recruitment of slow type I units has been observed during submaximal eccentric muscle contraction in humans [6,7]. If this is also the case during maximal eccentric muscle contraction remains unclear [4,8].

Following prolonged heavy-resistance strength training the suppression in motoneuron activation during eccentric muscle contraction is reduced [4] in parallel with an increase in neural drive (iEMG) [4,9,10]. This likely explains the increase in maximal eccentric muscle strength generally observed in response to heavy resistance training [2,4]. Notably, maximal eccentric muscle strength appears to remain unchanged following low-resistance strength training [2].

The combination of isokinetic dynamometry and simultaneous EMG recording in representative agonist-antagonist muscles allows to estimate the stabilizing joint moment generated by eccentric co-contraction of antagonist muscles during isolated joint extension. Thus, in maximal knee extension, coactivation of the antagonist hamstring muscles appears to provide substantial antagonist joint moment [11,12], which likely assists the ACL in counteracting anteriorly directed shear forces at the knee joint. Furthermore, following resistance training the differential pattern of medial versus lateral hamstring muscle coactivation changed in a manner that favoured a reduction in ACL stress. Thus,
antagonist coactivation was selectively reduced in the medial hamstrings (semitendinosus), thereby potentially reducing the magnitude of internal tibial rotation [13].

References

Neuromuscular performance in research and clinical application

A. Gollhofer
Department of Sport Science, University of Freiburg, Germany

Neuromuscular adaptation following strength training has been widely discussed in the literature. In strength training it has been shown that adaptation processes of the neuro-muscular system may be attributed to mechanisms based on either neuronal or muscular aspects (Sale 1992). It is well agreed that the force capability of maximum voluntary contraction (MVC) is largely dependent on the cross sectional area of the recruited muscle fibres and that recruitment and firing rate of the active motoneurons determine the rate of force development (RFD) (Enoka & Fuglevand 1993). Both aspects address primarily the contribution of the efferent part of activation.

From a neuromuscular perspective, the actual excitation of the motoneuronal system is determined by both efferent and afferent activation processes. In most of the classical strength training papers, the mechanisms associated with alterations in the efferent, voluntarily generated activation are determined as the responsible factors for neuronal adaptations. The precise role of afferent contributions is not as well understood.

For long years, the determining role of sensory feedback to modulate muscular activations has been studied in locomotion and in postural tasks. Questions, to what extent alterations in afferent feedback may also enhance the motor output, understood as a positive feedback mechanism, have not been addressed extensively in the strength training literature extensively. As an exception, the functional importance of active sensory, stretch related feedback has primarily been investigated only for one specific type of muscular action, the stretch-shortening cycle (Gollhofer et al 1987; Komi 1984). Based on isolated studies the important role of stretch reflexes for regulation of stiffness of the tendomuscular system has been verified. Nichols (1987) demonstrated that an electrically stimulated muscle responds to ramp stretches with linear, spring like tension increments, only if the muscle has remained its intact afferent reflex system. Hoffer and Andreasson (1981) revealed under eccentric conditions that the net contribution of stretch sensitive activation under eccentric conditions is considerably important amongst a large range of other operating forces.

Despite the apparent importance of afferent neuromuscular activation most of the strength and power training studies usually do not focus on the issue whether sensory contributions, provided by proprioceptive mechanisms, may influence the production of force and power itself. Therefore, the major purpose of the presentation is to describe the adaptations of the neuromuscular system after proprioceptive training programs. Functional considerations will be elaborated in order to reveal relevant mechanisms how apparent improvements in proprioceptive sensitivity can be beneficial for normal muscular activation processes as well.

In the prevention of incidences of injuries to the ankle joint ligaments several authors favour the idea that especially in situations were the ankle joint complex is prone to get sprained an effective protection could be provided by the muscles encompassing this joint. In order to achieve effective muscular stiffness in the course of the tilt movement a rather fast rate of force development is more preferable than high muscular forces.

Theoretically promoted as "proprioceptive facilitation" of the neuronal contribution of the various receptor types in the joint complexes, in the tendon and in the muscular structures, proprioceptive training is frequently applied in rehabilitation. Similar to the argumentation in plyometric strength training, this type of training aims to improve the efficacy of the afferent contribution in the neuromuscular control, in order to attain better limb control and to achieve an early access to the muscles encompassing joint complexes.

In a series of experiments, we have investigated the effects of proprioceptive training interventions on the neuromuscular properties. Specific emphasise was given to the evaluation of afferent and efferent alterations. In seve-
ral training studies the functional adaptations were determined on the basis of strength and emg measurements. Maximum voluntary contractions, posture stabilization and artificial loading of knee and ankle joint complexes was tested.

The results indicate that after training, the mechanical stiffness of the joint complexes was increased, concomitant with a significantly enhanced proprioceptive control during dynamic posture stabilisation. In the MVC tests it was consistently observed that capability to produce the maximum rate of force development in shorter time was improved.

The mechanical importance of enhanced afferent gains in the neuromuscular control seems to reflect the changed ability of the neuromuscular system to activate the muscles more efficiently at the onset of force development. Especially in disturbance conditions a rather fast access to the muscles may be important to stiffen joint complexes. Not only in rehabilitation, even more pronounced in athletic training, i.e. in alpine skiing, proprioceptive training programs may be an efficient tool to improve the agonist/antagonist intermuscular communication. This may have functional importance in all sport disciplines with explosive power demands.

From a physiological point of view, muscle spindle afferents are not simply stereotype responses to unexpected stretches. Embedded in the neuromuscular pattern they provide high stiffness in the tendomuscular system, not only in the SSC. Moreover, they are highly efficient in the isometric force development.
Muscle strength and explosive force and power decrease with increasing age, especially at the onset of the sixth decade in both genders. The decrease in muscle strength is largely related to the decline in muscle mass perhaps related to age-related changes in hormone balance and declines in the intensity of physical activities. The decline in muscle mass is thought to be mediated by a reduction in the size and/or a loss of individual fibres, especially of type II fibres. Age-related declines in strength may also be due to the decreased activation of the agonists recorded during maximal voluntary efforts. In addition, there appears to be an age-related increase in antagonist coactivation, especially during dynamic actions.

Progressive strength training not only in young adults but also in middle-aged and older men and women leads to large increases in strength of the trained muscles. A major part of the large strength gains during the initial weeks of strength training may be accounted for by adaptations in the neural pathways acting at the supraspinal and spinal levels in the nervous system. Training-induced neural adaptations can be measured using specific recordings of voluntary actions combined with electrical stimulation procedures (e.g. force produced by supramaximal single pulses given during maximal voluntary efforts) or using invasive techniques, in which needle or fine-wire electrodes are inserted into muscle (allowing single motor unit recordings) or indirectly, by analyzing changes occurring in electromyographic (EMG) activity of the trained muscles recorded during maximal voluntary muscle actions. The degree of resistance training-induced muscle hypertrophy can be measured by analyzing the size of individual muscle fibers or by analyzing the cross-sectional area of the muscle by a means of an ultrasonic apparatus, CT or magnetic resonance imaging (MRI).

Although the actual forms of neural adaptations are difficult to reveal, strength training does lead to changes in the quantity and quality of activation so that 1) activation of the agonists is increased and/or that there is 2) a reduction in coactivation of the antagonists and/or 3) an improved coactivation of the synergists. Although the EMG is a complicated signal and represents only an average of the maximal neural activation of the muscle, the increase in the quantity of EMG suggests that the number of motor units recruited have increased and/or motor units are firing at higher rates or a combination of the two has occurred. Strength training, especially in the elderly can lead to large decreases in the antagonist coactivation enhancing the net strength production of the agonists. Strength training-induced changes in the EMG can also be important indicators of the specificity of training. The increases in the maximum EMG activity recorded during the bilateral actions have taken place to a greater extent in bilaterally than unilaterally trained subjects, while the increases in the unilateral EMG were large for both right and left leg only in unilaterally trained subjects. This suggests that the specificity between the bilateral and unilateral strength increases seems to have a neural basis. To induce increases in explosive force and power, strength training also in older people should in part be combined with exercises performed with lower loads but with higher action velocities.

Muscle hypertrophy also accounts for the strength gains, since the increase in the muscle CSA during strength training comes primarily from the increase in size of individual muscle fibres of type II and I, and to some degree from the increase in non-contractile connective tissue between the fibres, probably with no addition in fibre number. Skeletal muscles of older men and women retain the capacity to undergo training-induced hypertrophy, when the volume, intensity, and duration of the training are sufficient. Some caution should be exercised when interpreting fibre size or muscle CSA data obtained only at one particular portion of the limb, since training-induced muscle hypertrophy can be non-uniform along the belly of the muscle, and different even between the individual muscles of
the same muscle group. Persons with a higher relative proportion of type II fibres may show larger increases in
the CSA of the trained muscle than those possessing a lower proportion of these fibres in their muscles. Since
the increase in strength can be greater than the degree of muscle growth, it is also possible that in addition to
the increased voluntary muscle activation, architectural changes, e.g., changes in pennation angle of the muscle
fibres, may take place during training. Although blood concentrations of circulating anabolic hormones and growth
factors are diminished with aging, no changes are usually observed during strength training of a few months in
the concentrations of serum total and free testosterone, insulin, insulin-like growth factors, and growth hormone(s).
However, a low level of testosterone may be a limiting factor, since older women having lower basal levels may not
be able to produce the same gains in muscle mass and strength as women having higher testosterone levels.

The benefits of maintaining or improving maximal strength and power in aging people include correction of gait
disturbances, prevention of falls, improved stair climbing and walking, increased mobility, as well as improved
performance of activities of daily living. Ongoing resistance training in the elderly may be an excellent method of
counteracting not only the losses of strength but also that of functional capacity normally associated with aging, and
even to serve to delay the threshold for dependency by several years.
The rehabilitation of injuries in athletes (i.e. after reconstruction of the ACL or the Achilles tendon) has two main purposes. First, as in a normal patient population, an optimal healing of the formerly injured and/or reconstructed structures and the regaining of joint stability has to be enabled. Secondly, the sports-specific reconditioning of the performance-related muscles or muscle groups is of great interest. Both aims represent a challenging demand for the medical staff since scientific literature and practical experience indicate that recovery of preinjury level is very difficult to reach. Besides coordination and endurance training, strength training seems to have a very important function in regaining the neuromuscular basis for participating in high-performance activity.

Early phases of rehabilitation are characterized by therapeutic interventions to reduce joint effusion, swelling, pain, and, but not in all injuries, to regain full range of motion (ROM). In this time period, strength training is limited to exercises for increasing the voluntary activation of target muscles (i.e. the M.quadriceps femoris after ACL-reconstruction) in isolated and complex situations. Further, strengthening exercises may help in improvements in sensorimotor function, especially the appropriate integration of afferent information into adequate motor control strategies. Due to the healing process and deficits in joint stability strengthening exercises should be conducted at low intensities and slow movement speed within a injury-specific limited ROM. However, strength training has to be applied very carefully since i.e joint effusion and pain may induce inhibitory effects on target muscles (i.e. inhibitory effect of knee joint effusion on the M.vastus medialis [1]). In such cases, too much active exercise may reinforce compensatory muscle activity (i.e. in the gait cycle) which, in turn, could increase the load on passive structures (i.e. the cartilage).

In the course of the rehabilitation continued healing of the formerly injured structures allows progressive loading of the neuromuscular system and the respective joint step by step (i.e after ACL-reconstruction). In this phases the training schedule has to integrate more and more the specific demands of the respective athletic activity. In general, the basis of future success of an athlete after having finished the rehabilitation process is the attainment of the highest possible state of muscular power (rate of force development and maximal movement velocity based on sufficient joint stability). In this sense, injury not only has deleterious effects (i.e. decrease of muscle mass and voluntary activation capacity) for the muscles of athletes. Instead, immobilization and inactivity is known to increase the percentage of the fastest human muscle fibres, the TypeIIx-fibres. Proper usage of strength training may help to maintain this relatively fast fiber spectrum. In detail, fatiguing training methods should be avoided since it is well known that such a training will reduce the percentage of TypeIIx-fibres dramatically. Consequently, training volume and fatigue should be limited in strength training of athletes in rehabilitation.

According to the results of Hortobagyi et al. [2] it seems that pure eccentric training has some important advantages in the retraining of the neuromuscular system. These researchers were able to show that the eccentric contractions induce the highest enlargements in the fibre areas of TypeIIa and TypeIIx fibres. Further, eccentric training is characterized by a lower metabolic cost compared to concentric actions at the same load and consequently avoids marked fatigue. For the success of the rehabilitation process, training with eccentric contractions seems to have further advantages since a lot of patients suffer from marked decreases in eccentric muscle function.

Another possibility to work with low-fatiguing strength training in rehabilitation of athletes is to use a programme with variation of the training methods within a training week. In a recent study, we observed after a strength training with a combination of different strength-/power training methods (including specific eccentric stimuli) similar improvements in maximum strength (1RM) and better improvements in maximal movement velocity compared to a traditional strength training group [3]. Further, whereas the high load-group showed a marked decrease in TypeIIx-
fibres, the reduction in this fibre-type in the group with the combination of power training methods remained low. This results indicate that variable force-/speed-requirements and variable movement patterns are able to increase training efficiency with respect to muscular power. The accompanying greater overall muscle loading may also allow a better development of adequate motor control strategies which, in turn, seems to be of great importance for the injured athlete.

References

Neuromuscular adaptations to reduced activity

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It is well known that after a period of reduced activity (limb immobilization, bed rest, spaceflight), neuromuscular performance is decreased due to a loss of muscle mass. More recently, much attention has been devoted in human-subject experimentation to possible changes in the neural command of muscle contraction [2,7]. The evidence supporting a role for neural mechanisms in the adaptations that accompany a chronic reduction in neuromuscular activity appears from the observation that when a joint is immobilized for several weeks, the decline in muscle force and corresponding EMG activity, decrease to a greater extent when tested by a maximal voluntary contraction (MVC) than by an electrically-induced tetanic one [2]. A further argument in favour of impaired neural activation after immobilization is the observation that 4 weeks of limb immobilization produce a substantial decrease in MVC force that was associated with a rather limited degree of muscle atrophy but a greater reduction in the ability to activate the elbow flexor muscles [7]. These observations lend to the conclusion that the impaired musculo-skeletal function in reduced loading conditions cannot be attributed entirely to muscular changes, but that the decreased neural drive is partly responsible for the loss of force after a period of reduced muscular activity (see [4]).

An explanation for impaired neural activation is that, after a period of disuse, a subject becomes unable to activate maximally the motor unit population of a muscle. This suggestion is supported by the observation of a reduction in the interference pattern of intramuscular EMG during a MVC after several weeks of immobilization [2]. In addition to impaired motor units recruitment, a reduction in their maximal discharge frequency contributes to the neural changes [3]. Indeed, computer simulations show that this decrease can explain up to 40% of the total loss of force in hand muscles after 6–8 weeks of immobilization. However, specific adaptations occur since the range of discharge rate modulation is reduced more drastically in motor units with lower recruitment thresholds than in motor units with high thresholds [3].

When a limb is immobilized in a cast for several weeks, the muscles involve typically atrophy and show a decrease in their maximal force generating capacity, as attested by the reduction in maximal tetanic force [1,2]. This change is accompanied by a slowing of the contractile properties of the muscle since the maximal rate of tension development and relaxation are reduced. Although a greater degree of atrophy is sometime observed in slow twitch fibres [1], in hand muscles a reduction in twitch force was found for all motor units with a proportionally identical drop whatever their recruitment threshold [3]. The atrophy, associated with a reduced maximal generating capacity of the muscle, is mainly due to a decline in the rate of protein synthesis and an increase in the rate of protein degradation [6]. However, the loss of muscle tension appears to be due, not only to a net reduction in the number of cross-bridges between actin and myosin filaments [1], but also to a reduction in the tension generating capacity of each individual cross-bridge [6].

In conclusion, a period of reduced activity induces drastic alterations in muscle strength and speed. These alterations result not only from mechanisms associated with contractile adaptations, but also from neural changes. The relative contributions of these mechanisms are related to the duration and the unloading conditions of the inactivity period. From a practical point of view in physiotherapy, these observations emphasise the need to reduce the duration of the unloading and to maintain some activation during this period not only to minimise muscle atrophy, but also to preserve neural functions.
References

Speaker Abstracts
EMGs and strength patterns of the quadriceps during isokinetic extension of the knee in different contraction mode

P.-M. Dugailly\textsuperscript{a}, D. Mouraux\textsuperscript{a}, N. Llamas\textsuperscript{a}, J. Duchateau\textsuperscript{b} and E. Brassinne\textsuperscript{a}

\textsuperscript{a}Department of Physical Therapy and Rehabilitation, Erasmus Hospital, ULB, Brussels, Belgium
\textsuperscript{b}Research Unit on Neurophysiology, ULB, Brussels, Belgium

Introduction

In the literature, EMGs activity is mostly expressed in % of maximal voluntary contraction. Therefore, these data enable us to compare different population in terms of intensity or activity pattern.

Authors have reported EMGs signals during precise movements and contractions, concentric or eccentric.

Few clinical reports have investigated the differences of EMGs signals between concentric and eccentric contraction mode.

Nevertheless, comparison between electric signals and muscle strength has not yet been reported.

This study is designed to compare EMG activity and torque intensity for two types of contractions with regard to the instantaneous amplitude of the knee using an isokinetic device.

Methods

Twenty healthy male students (age: 25.2 ± 1.9; weight: 79.0 ± 8.1 kg; 177.8 ± 6.1 cm) participated in the study. They had no history of knee or hip injuries. All subjects were familiarized with isokinetic movements concentric or eccentric. Before the evaluation, the subject achieved a 10-minute bicycle warm-up and four pretest contractions. The tests consisted of 3 maximal dynamic contractions, respectively concentric and eccentric, at 60°/s with a 2-minute rest between each contraction mode. Both tests were accomplished using dynamometer type CYBEX NORM with a range of motion limited to 105°. The eccentric protocol was carried out using activ-assist procedure. All electrical activities were expressed in %MVC.

Results

This study demonstrates that neither EMG activity nor muscle strength were significantly different between the right and the left legs. In both concentric and in eccentric modes, no difference was found between vastus lateralis (VL) and vastus medialis (VM) activity. Compared to these data, rectus femoris (RF) activity shows significantly lower signals at identical angle of movements. Analysis of EMG patterns shows peak activity for VL and VM around 90° and 70° of knee flexion, respectively in concentric and in eccentric modes. For the RF, a flat curve is observed during all the movement in both contraction modes.

Comparison between total EMG (expressed by summing VL, VM and RF activities) and torque during the movement shows that in concentric mode, peak muscle activity appears at the beginning of the movements (around 90°) while maximal torque occurs at 70°. In eccentric mode, this activity is delayed and is nearing the peak torque.
Discussion

According to the literature, the results of this study demonstrate that the intensity of muscle activity is influenced by the type of contraction. Peak EMGs angle variations are also observed between concentric and eccentric mode and do not correspond to the peak torque angle. Moreover, different motor recruitment patterns of the quadriceps suggest an important influence of the methodology and the experimental conditions. In conclusion, analysis of EMGs muscles characteristics of the quadriceps might play an important role among concerned knee population.

References

Effect of a short-time eccentric training on the eccentric performance of the quadriceps

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Introduction

In isokinetic dynamometry, studies which show that eccentric (ECC) strength is superior to isometric for the quadriceps, seem to be a minority. Some studies suggest that the quadriceps is unable to be voluntarily fully activated. They conclude this from the presence of a tension-regulating mechanism which may be a protection for the muscular skeleton system. The lack of activation was showed by studies comparing maximal voluntary activation with electrical superimposed activation. In this regard, Amiridis and Westing [1,6] conclude that for the quadriceps, the maximal voluntary eccentric peak torque do not represent the maximal peak torque output. Sale suggests that the inhibition mechanisms could be modulated by training. The purpose of our study is to verify this hypothesis by analyzing the effect of a short-time eccentric training on the eccentric performance of the quadriceps.

Materials and methods

17 healthy male subjects (age: $25 \pm 2$ years; weight: $75 \pm 8$ Kg; height: $178 \pm 6$ cm) were divided in 2 groups: the eccentric group ($n = 11$) and the control group ($n = 6$). The two legs of each subject were tested 2 times with an interval of 2 weeks. The legs of the control group represented 12 control legs. In the ECC group, the strongest leg performed an isokinetic ECC training during the 2 weeks between the tests. The tests which were performed with a CYBEX NORM were namely: a maximum voluntary isometric (ISO) contraction ($60^\circ$ of knee flexion), an isokinetic Eccentric (ECC) and Concentric (CON) test at a speed of $60^\circ$/sec (R.O.M. = $105^\circ$). During those tests, the surface electromyographic activity was recorded from the vastus lateralis (VL), the vastus medialis (VM) and the rectus femoris (RF) by the NORAXON MYOSYSTEM 2000. The training consisted of 5 sets of 8 knee extensions, in ECC mode, 3 times a week, during 2 weeks. The training load was based on the best ECC performance made during the first session of tests. The first training session began at 70\% of this performance, the second was about 80\% and the third reached 90\%. The last three sessions were performed with maximal contractions. A student t-Test was used to analyze our results.
Results

![Graphs showing peak torque and EMGs activity in eccentric mode](image)


Discussion

The trained leg (TL) gains were about 21% in ECC mode. No differences were found in CON or ISO modes. This finding supports the notion of mode-specificity of training. These gains were about 3.5% per session, which is superior than in the literature [2,3,5]. The explanation of the gain in a short period is probably linked to neural adaptations. The lack of significant differences in EMG didn’t allow us to show an inhibition decrease. The untrained leg (UTL) gains (13%) show presence of the cross-education phenomenon which suggests a central neural adaptation and also a learning effect. The control leg (CL) gains (6%) suggested the presence of a learning effect which can be explained by the short period between the test sessions.

References

Isokinetic eccentric exercises in treating chronic tendinitis

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Department of Physical Medicine and Rehabilitation, CHU Liège, Belgium

Resulting from high demands placed on tendons during many movements, chronic tendinitis represents one of the most common overuse injuries in sports and in some specific professional occupations. Many treatment protocols have been described but classical conservative treatments have in common being “passive” with little possibility to modify the tendon histological structure. This statement seems in contradiction with an aetiopathogenic theory proposing insufficient tensile strength of the tendon exposed to external loads which can damage it [1]. The purpose of this study was to determine the effectiveness of eccentric training models in treating various types of tendinitis and evaluate protection from re-injury when returning to causal activities.

Thirty-four patients diagnosed with chronic tendinitis (9 Achilles, 10 patellar and 15 epicondylian) causing pain during specific activities participated in this study. Each case was characterized by a long duration of symptoms (range, 3 to 15 months) and failure of conventional treatment when returning to causal activities. Evaluation consisted of:

– determination of amount of pain using a visual analogic scale (graded from 0 to 10 arbitrary units, a.u.),
– measurement after treatment of isokinetic concentric and eccentric performances on the muscle groups corresponding to the pathological tendon,
– patient assessment about the evolution of symptoms and functional potential 3 months after return to causal sport or occupational activities, in comparison with status before treatment,
– bilateral ultrasonographic examination of Achilles, patellar and epicondylian tendons was performed before and after eccentric program.

The eccentric training model given to the injured side was achieved by uses of isokinetic dynamometer and based on 20 to 30 sessions with progressive increase of load and speed parameters (a standardized protocol was used for each localization of tendinitis).

At the end of treatment, we observed a significant reduction of pain evaluated on a visual analogic scale: the average initial values were superior to 6.5 a.u. and final score inferior or equal to 2.5 a.u.. Only 4 recalcitrant cases at 4 a.u.; 3 of them presented intratendinous calcifications and 2 finally benefited from surgical treatment. 74% of patients were completely relieved or presented marked decrease in symptoms when returning to sport and occupational activities, and only 12% observed no change in their clinical state. Isokinetic assessment revealed no significant concentric or eccentric peak torque asymmetries between involved and non-involved sides. In comparison with pretreatment ultrasound observations which showed systematic hypoechoic lesions and thickness, 14/34 patients recovered homogeneous tendon structure and normalization of the diameter; 15 presented improvement in echostructure.

The final goal in treating tendinitis is a safe and painless return to sports or occupational activity with the maximal restoration of physical fitness components affected by the injury. Most forms of treatment remain “passive” as to tissue structure adaptations and there is only limited evidence as yet to support satisfactory results with these classical techniques. In the present study, it appears that eccentric training programs proposed, with intention to adapt tendons to increased loads, had a good short-term effect on the painful condition in the 3 selected suffering tendons: Achilles, patellar and epicondylian. While understanding the adaptive mechanisms requires further fundamental investigations, the clinical data strongly suggest effectiveness of this eccentric training model and the necessity to
incorporate it in the management of chronic tendinitis.

Reference

Eccentric isokinetic strength training in stroke patients: Effects on motor function

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\textsuperscript{c}Laboratory of Biometry, ISEPK, ULB, Belgium

Introduction

In stroke patients, weakness is recognized as a limiting factor in the rehabilitation. This deficit of strength is the result of spasticity imposed by the antagonist muscle group. Strength training is always controversial in stroke rehabilitation because it seems to interfere with coordination and timing in motor control. Nevertheless, authors suggest some advantages in training stroke patients using eccentric loads. During concentric but not eccentric actions, restraint of antagonist muscles imposed by stretch reflex, increases with increasing velocities. The purpose of this study is to investigate the eventual functional effects on stroke patients following eccentric isokinetic rehabilitation of the quadriceps.

Methods

We used a randomized volunteers sample of 9 stroke survivors who followed rehabilitation including loading and unloading exercises on their affected leg producing both CON and ECC contractions. These patients were divided in two groups. One Group ($n=4$) trained using eccentric movements three times a week during 6 weeks and the second served as control group ($n=5$). All subjects were screened to ensure they were at least 3 month post stroke. They were independently ambulatory without assistance over a 14 meter distance and were able to climb alone up and down a stair. They had no orthopedic lesion and no cognitive trouble. The training was performed three times a week during 6 weeks on alternate days. The eccentric contractions were performed using an isokinetic dynamometer Cybex Norm\textsuperscript{c}.

Concentric and eccentric peak torque were evaluated using the same dynamometer before and after the training period of both legs. This strength parameter was measured at 60\textdegree/s in concentric mode for quadriceps and hamstring and at 30\textdegree/s in eccentric for the quadriceps only.

Functional parameters (walk speed, length of step, up and down stair test, body weight distribution ratio (paretic side/ non paretic side) were measured before, after and 4 weeks after the end of the training. We also asked the patients to evaluate their functional ability during walking on visual analogic scale (VAS).

Results

At the end of the training, peak torque for the non hemiparetic leg did not improve in neither of the two groups. There were also no significant changes to the affected side in these groups. The torque ratio (hemiparetic side / torque non-hemiparetic side) showed a significant improvement ($p < 0.05$) at 60\textdegree/s in concentric. For the trained group, functional parameters showed a significant increase of the walk speed ($p < 0.05$), the climbing down stairs...
(p < 0.01) and VAS (p < 0.01). These improvements were stabilized significantly (p < 0.01) 4 weeks after the training.

### Isokinetic Data

<table>
<thead>
<tr>
<th></th>
<th>Unimpaired before</th>
<th>Unimpaired after</th>
<th>Impaired before</th>
<th>Impaired after</th>
<th>Unimpaired before</th>
<th>Unimpaired after</th>
<th>Impaired before</th>
<th>Impaired after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q ecc 30°/s</td>
<td>151</td>
<td>148 (−2%)</td>
<td>157 (+23%)</td>
<td>141</td>
<td>136 (−4%)</td>
<td>83 (+14%)</td>
<td></td>
<td></td>
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<tr>
<td>Q conc 60°/s</td>
<td>135</td>
<td>127 (−6%)</td>
<td>95 (+8%)</td>
<td>105</td>
<td>105 (0%)</td>
<td>36 (−3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ham conc 60°/s</td>
<td>68</td>
<td>70 (+3%)</td>
<td>44 (+38%)</td>
<td>61</td>
<td>64 (+5%)</td>
<td>8 (−33%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conc Ratio</td>
<td>0,5</td>
<td>0,35</td>
<td>0,55</td>
<td>0,44</td>
<td>0,56</td>
<td>0,27</td>
<td>0,6</td>
<td>0,22</td>
</tr>
<tr>
<td>Functional Ratio</td>
<td>0,48</td>
<td>0,27</td>
<td>0,51</td>
<td>0,28</td>
<td>0,42</td>
<td>0,21</td>
<td>0,47</td>
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### Functional Outcome

<table>
<thead>
<tr>
<th></th>
<th>Trained before</th>
<th>after 6 weeks</th>
<th>after 10 weeks</th>
<th>Untrained before</th>
<th>after 6 weeks</th>
<th>after 10 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>velocity (km/h)</td>
<td>3,37 (100%)</td>
<td>134%</td>
<td>136%</td>
<td>2,58 (100%)</td>
<td>99%</td>
<td>100%</td>
</tr>
<tr>
<td>Step length (cm)</td>
<td>115 (100%)</td>
<td>110%</td>
<td>111%</td>
<td>93 (100%)</td>
<td>102%</td>
<td>102%</td>
</tr>
<tr>
<td>Up (step/min)</td>
<td>70 (100%)</td>
<td>119%</td>
<td>121%</td>
<td>41 (100%)</td>
<td>102%</td>
<td>102%</td>
</tr>
<tr>
<td>Down (step/min)</td>
<td>56 (100%)</td>
<td>145%</td>
<td>157%</td>
<td>42 (100%)</td>
<td>105%</td>
<td>98%</td>
</tr>
<tr>
<td>ratio (HS/NHS)</td>
<td>91%</td>
<td>93%</td>
<td>98%</td>
<td>67%</td>
<td>66%</td>
<td>67%</td>
</tr>
<tr>
<td>VAS (ability)</td>
<td>5,75</td>
<td>7,5</td>
<td>–</td>
<td>6,2</td>
<td>6</td>
<td>–</td>
</tr>
</tbody>
</table>

### Discussion

The result of the present study shows that the concept of eccentric training may be more suitable for stroke patients because most movements of daily life include eccentric contractions (transfers, sit down, stairs, gait, ...). Eccentric training seems to be more specific and provide economical movement for better independence. Nevertheless, despite the fact that our samples were randomized, it seemed that our trained group had a better function at the beginning of the study. Is it the reason why their recovery was more important than in the second group? This study should be continue to confirm the real effect of isokinetic training in complement of rehabilitation.

### References

Sciatica induced pain has an important role in dysfunction of the lumbar spine. Pain and disuse lead to changes in muscular stabilization decreasing the muscular support of the spine. Thus, the present study evaluated the association between force production characteristics of the trunk muscles and pain 2 and 14 months after the lumbar disc surgery.

One hundred and seventy two patients were evaluated two months after the operation and 138 of them were re-evaluated 1 year later. Maximal isometric strength and force-time curves of the trunk flexors and extensors was measured with the dynamometer. Endurance strength of the trunk muscles was measured by calculating the repetition maximum. Back and leg pain were assessed on Visual Analogical Scale (0–100 mm) before, 2 and 14 months after the operation. The mean (SD) preoperative back and leg pain values were 58 (29) and 70 (26) mm, respectively. In the analysis 2 months after the operation the patients were divided in two groups according the pain: VAS $< 10$ mm was considered as painless (PL) and VAS $> 10$ mm as painful (PF) groups.

The mean (SD) maximal isometric strength values of 505 (202) N and 465 (165) N in the trunk extensors and flexors were significantly higher in PL compared to the respective values of 347 (191) N and 370 (178) N in PF ($p < 0.001$) 2 mo postoperatively (Fig. 1). After the 1-year follow-up PL showed increased values in the trunk extension and flexion strength of 15% (ns.) and 13% (ns.) and in PF of 24% ($p < 0.001$) and 16% ($p < 0.001$). At 14 mo the differences between the groups were statistically significant ($p < 0.001$). The force-time curves of the trunk extensors of PL were located significantly higher at 2 mo (between 400–700 ms; $p < 0.050 – 0.016$) and 14 mo (200–700 ms; 0.032–0.001) compared to the values of PF (Fig. 2). Both groups showed increased force values in the early portions of their force-time curves. In the trunk flexors the differences between the groups were minor. PL performed 39 (19) reps at 2 mo, and 47 (23) reps at 14 mo for the trunk extensors. The corresponding 25 (23) and 35 (25) reps in PF were significantly lower ($p < 0.001$). The differences in the repetitive sit-up test were minor between the groups. Postoperative back and leg pain of 3 (3) and 3 (3) mm in PL and 31 (24) and 26 (24) mm in PF at 2 and 14 mo respectively remained unchanged in both groups.

![Fig. 1. Isometric trunk extension and flexion strength.](image-url)
The PF patients had 2 months after the operation lower values in both maximal trunk flexion and extension forces, as well as in the force-time curve and dynamic endurance strength of the extensors compared to PL patients. Although force production capacity of the trunk muscles in PF patients recovered during the follow-up, the differences between the groups even increased one year later. The amount of postoperative physical activity and employment status did not differ between the PL and PF groups. Thus, it seems that the intensity (load) of habitual physical activities was not high enough (remained too low) that might be needed for these postoperatively painful patients for the recovery of their strength to the level of their painless pears.
Isokinetic evaluation of hip muscles in patients with coxarthrosis

Y. Henrotin\textsuperscript{a,b}, B. Rale\textsuperscript{b}, J.-E. Dubuc\textsuperscript{b}, J.-L. Croisier\textsuperscript{a} and J.-M. Crielaard\textsuperscript{b}

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\textsuperscript{b}Physical Therapy and Rehabilitation Department, Princess Paola Hospital, Marche-en-Famenne, Belgium

Until now, many papers have reported the relationship between knee osteoarthritis (OA) and muscle weakness, but none have studied this relationship in hip OA. In a previous study \cite{1}, we have clearly demonstrated that quadriceps performances were commonly reduced in patients with gonarthrosis, whereas knee flexors were not systematically affected. It was also reported that the knee flexors deficit was strongly correlated with the disability giving evidences for flexors strengthening in the management of patients with knee OA. From this study, it was hypothesised that muscles weakness could induce joint instability, decrease the absorbing capacities and then worse the symptoms. This study was designed to investigate the relationship between hip OA and muscle performances.

The isokinetic assessment of hip muscles was performed in 21 patients candidates for hip prosthesis. The average age of the tested patients was 64.1 (44–79) years old. All patients had a unilateral symptomatic (SYMP) coxarthrosis corresponding to the clinical and radiological criteria of the American College of Rheumatology. Concentric muscle performance expressed as peak torque (N.m.) was assessed by isokinetic dynamometer (Kin Trex 1000) and recorded at the velocities of 30°/s and 90°/s. The asymmetry for peak torques (difference between SYMP and ASYM limb) was calculated and correlated with the algofunctional status (Womac index) and the radiological score (Altman score) of the patients. The performance of the osteoarthritic patients was also compared with those of age-matched subjects without hip complaints (controls).

All OA patients reached the velocity of 30°/s but only 50% the highest speed of 90°/s. For this reason, only the data recorded at 30°/s have been considered. At 30°/s, the peak torque of SYMP OA flexors, extensors and adductors were found to be reduced by 25, 20 and 15% respectively compared with the healthy (ASYMP) one (Table 1). When hip OA group was compared with the controls group, it was observed that overall muscles of the SYMP limb showed a strong weakness (> 30%) whereas only the abductors of the ASYMP limb were significantly weakened. By comparison with the controls group, the ratios Flex/Ext and Abd/Add were not modified in the OA group. The muscle deficits were not correlated between them and with the length of the symptoms or the Womac index.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Flexors</th>
<th>Extensors</th>
<th>Abductors</th>
<th>Adductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYMP OA vs ASYM</td>
<td>−25%*</td>
<td>−20%*</td>
<td>−11%</td>
<td>−15%</td>
</tr>
<tr>
<td>SYMP OA vs CONTROLS</td>
<td>−36%*</td>
<td>−34%*</td>
<td>−30%*</td>
<td>−30%*</td>
</tr>
<tr>
<td>ASYMP vs CONTROLS</td>
<td>−0.05%</td>
<td>−17%</td>
<td>−20%*</td>
<td>−18%</td>
</tr>
</tbody>
</table>

*The groups were significantly different with a $p < 0.05$ (t-test of Student).

We can conclude that in coxarthrosis overall muscles of the hip were affected. Furthermore, the muscles of the opposite asymptomatic limb were also weakened compared with age-matched controls. Taken together, these results
suggest that coxarthrosis is a global disease affecting not only periarticular muscles but also distant muscles. This finding gives a strong evidence for a global management of OA patients including strengthening exercises of the opposite asymptomatic limb.

Reference

The effects of intensive volleyball practicing on the muscular balance of the rotator cuff of the shoulder

C. Dupuis\textsuperscript{a,b}, C. Tourny-Chollet\textsuperscript{a,b}, N. Biette\textsuperscript{a,b} and F. Beuret-Blanquart\textsuperscript{a}
\textsuperscript{a}GRHAL, Faculty of Medicine, University of Rouen (France)
\textsuperscript{b}CETAPS, UPRES JE 2318, Faculty of Sport Sciences, University of Rouen (France)

The RI/RE shoulders ratio of nonathletes has been established at 3/2 [5]. This reference value can vary in the case of a sportsman without any pathological implication. It is a consequence of intensive sport practicing. The techniques of the different sports account for the differences of rotator cuff ratio, between pitchers and tennis players for instance [2,5]. Shoulder injuries are numerous among volleyball players because the rotator cuff muscles play an important role in the production of the ball speed in volleyball. In order to restore the rotator cuff balance of volleyball players, it is essential to know the healthy muscular ratio of volleyball players. This study aims to determine the muscular ratio of the rotator cuff of volleyball players.

The experimental population is composed of 8 volleyball players, 8 judokas, and 8 nonathletes. The experimental data are recorded with an isokinetic dynamometer Kin-Com\textsuperscript{©}. The subject is sitting, shoulder set in a 90° abduction and on the plane of the scapula [4]. The tests are made at 90°/s on a range of motion of 110°: assessment of RI and RE, in concentric and eccentric modes, for the dominant and nondominant arms. The data processing is made on the whole range of motion, on the end of medial and lateral range of motion (the last 30 degrees).

Fig. 1. Conventional and functional ratio of dominant arm on the whole range of motion.

No statistical difference of strength between dominant and nondominant arms appears in the results. Volleyball players and judokas show better results of strength than nonathletes on all types of assessments. Conventional and functional ratio of volleyball players and nonathletes are close. They differ from ratio of the judokas.

The results of average torque moments of RI conc and RE ecc are according to literature [1]. On the contrary, the strength of RI ecc and RE conc are higher than the values found in literature. That difference in the results explains a ratio RI/RE inferior to 1. The position of the subject during the assessment is an element, which explains that difference. We can conclude from those results that an intensive volleyball practicing has an effect on the develop-
ment of the strength of rotator muscles, while preserving a muscular balance near to the one of nonathletes.

References

Strength profiles of the knee muscles linked to the playing position of soccer players

N. Biette\textsuperscript{a,b}, S. Sangnier\textsuperscript{b}, C. Dupuis\textsuperscript{a,b} and C. Tourny-Chollet\textsuperscript{a,b}

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The soccer imposes high muscular demands on legs. The muscular profiles of the soccer players is linked to their playing position \cite{2}. In general, the playing positions studied in literature are divided in three horizontal areas: defence players, midfield players, attack players. However, the playground may be divided in vertical areas. The soccer player is an axial player or a lateral player.

It was shown that strength of peri-articular knee muscles take an important rule in maintaining joint stability \cite{1}. Knee flexors/knee extensors ratio is commonly used to evaluate joint stability.

The aim of our study was to identify muscular profile according to vertical playing position.

Sixteen soccer players of the universitary championship 2000 team winner participated in this study. They were divided in two groups of 8 players: axial group and lateral group. An isokinetic dynamometer (Kin Com \textsuperscript{R} 500H) was used to carry out the strength of knee extensors and flexors muscles. The dominant leg was tested for all subjects. The tests were carried out at 30°/s, 60°/s, 120°/s and 180°/s in two contraction modes, concentric and eccentric. The ROM of the concentric test was 0–80°. The eccentric ROM was reduced from 25° to 70° (0° corresponding to the full extension), to prevent muscular injuries. This protocol permits the maximal efficacy angle of knee extensors muscles (65–75°) and knee flexors muscles (30–75°) \cite{3}.

The knee extensors average torques are different between both group according to the speed: the results are greater for the lateral group at 30°/s and 60°/s in both contraction modes. At 120°/s and 180°/s, the axial group results are better in both contraction modes. However, there is no statistically significant difference between both groups. The concentric knee flexors average torques did not reveale intergroup significant difference, nevertheless, the lateral group are systematically stronger than the axial group at four speeds. The eccentric knee flexors average torques show significant differences ($p < 0.05$) at 30°/s and 60°/s; the lateral group are stronger than the axial group.

The ratios indicate no significant difference between both groups for all speeds. However the lateral group ratios are always greater. It may be explained by the knee flexors torque greater and the knee extensors torque equal to the axial group.

The lateral players carry out more oblique sprints, more lateral movements than the axial group: these actions impose high demands on the knee, in joint positions which request higher joint stability. The knee flexors take part in these actions in braking the knee extensors.

References

\begin{itemize}
\end{itemize}
Glycogen utilization and composition of skeletal muscle in elite junior alpine skiers

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\textsuperscript{b}Clinic of Rheumatology, Leukerbad, Switzerland

Introduction

During competitive alpine skiing, the load on skeletal muscles is very high. Compared to other competitive sports, muscle recruitment pattern during alpine skiing is very special and characterized by a preponderance of eccentric over concentric activity [1]. In the view of the particular requirements of elite alpine skiing the scientific basis, on which training regimes and testing protocols are based, is narrow and not abreast with the recent developments in materials and technique.

Methods

In the course of the study “Allalin 2000”, we investigated the physiology of modern alpine skiing on elite junior alpine skiers. Endurance and power tests were performed before and after a single but exhaustive training day on skis. During the training day, the athletes performed 16 slalom runs and muscle biopsies were taken from \textit{M. vastus lateralis} before, after 4 and after 16 runs. Muscle glycogen content, fiber type composition and fiber cross-sectional area were determined. Race time was recorded for each run to determine ski specific performance.

Results

\begin{itemize}
  \item The training induced reduction in muscle glycogen content was highest in athletes performing best during slalom runs. Reduction in glycogen content was higher in type I than type II fibers. Glycogen was almost undetectable in some type II fibers.
  \item The ratio of type II to type I cross-sectional area, maximal power output during a endurance test and jump performance in a counter-movement jump-test correlated significantly to ski specific performance ($P < 0.05$).
  \item No significant relationship was found between fiber-type composition (mean values: 65% type I, 35% type II) and ski specific performance.
\end{itemize}

Discussion

Our results indicate that during competitive alpine skiing the type I muscle fibers are highly activated. Especially high performance athletes must take care to refill glycogen stores by optimizing the regeneration phase after training. Both high oxidative capacity (endurance, type I fibers) and muscle hypertrophy (power, type II fibers) seem to be the best predictors of performance in competitive alpine skiers.

Reference

Study of EMG activity of the hamstring during isokinetic movements of the knee

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Introduction

Search on electromyography surface signals (EMGs) during isokinetic evaluation is not very developed in the literature. The EMGs can give us interesting neuromuscular information on the mechanisms responsible for the production of the force, according to the speed and the contraction mode. The goal of this study is to establish isokinetic and EMG characteristics of the hamstring in order to use them as reference for comparison with subjects suffering from the knee disturbances.

Materials and methods

Population: 20 male subjects (age: 23.5 ± 1.7 year; weight: 73.3 ± 10.5 kg; height: 180.1 ± 7 cm). Our study was carried out using a Cybex Norm® isokinetic dynamometer coupled with an apparatus for recording and processing of the electromyographic signal (Noraxon Myosystem 2000®). The electrodes are placed on the mass of hamstring, halfway between the gluteal fold and the fossa poplitea. EMG activity of hamstring is recorded on all the range of motion (0–105°) and is expressed in percentage of the maximal voluntary contraction (%MVC) (preliminary realised at 30° flexion). The subjects warm up and are familiarised with the various types of contractions. We used speeds of 60°/s, 180°/s and 300°/s in concentric and eccentric mode (in activ-assist mode). For each speed, 3 maximal contractions were carried out. The statistical tests are carried out by using analyse of variance (ANOVA).

<table>
<thead>
<tr>
<th></th>
<th>PT (Nm)</th>
<th>EMG (%MVC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conc. 60°/s</td>
<td>123.9 ± 23.9</td>
<td>77.7 ± 16.0</td>
</tr>
<tr>
<td>Conc. 180°/s</td>
<td>93.4 ± 17.4</td>
<td>75.6 ± 14.2</td>
</tr>
<tr>
<td>Conc. 300°/s</td>
<td>71.5 ± 12.7</td>
<td>72.8 ± 14.9</td>
</tr>
<tr>
<td>Ecc. 60°/s</td>
<td>162.5 ± 31.1</td>
<td>74.4 ± 20.4</td>
</tr>
<tr>
<td>Ecc. 180°/s</td>
<td>145.6 ± 31.8</td>
<td>65.8 ± 18.0</td>
</tr>
<tr>
<td>Ecc. 300°/s</td>
<td>135.0 ± 37.0</td>
<td>69.1 ± 18.8</td>
</tr>
</tbody>
</table>

Conc. = concentric; Ecc. = eccentric; PT = peak torque.

Discussion

In concentric mode, PT (Conc.) decreases with the increase of the speed while the EMGs remains stable. Kellis and Baltzopoulos also find a stability of the hamstring EMGs for speeds from 30°/s up to 150°/s. Rothstein and Smith also found these characteristics on the quadriceps and the biceps brachii. Thus, these results show that recruitment is
independent from the speed during concentric isokinetic exercise. In eccentric, our results show that PT Ecc. remains stable between 0 and 60°/s and decrease at 180°/s and 300°/s. The force-speed relationship of the hamstring during maximal eccentric efforts is prone to controversy. Many authors [1,2] find stable performances depending of speed, though few authors have used speeds as fast as 180 and 300°/s, which could explain the difference with our results. EMGs activity remains stable with the increase of the speed except between 60 and 180°/s where it decreases. This reduction could partly explain the reduction in PT (Ecc.). These results could be due to our population of not very sporting subjects. By contrast, Westing and Smith showed a stability of the EMGs in eccentric in function of speed with sporting subjects. EMG concentric activity is either equal or higher than the EMGs eccentric while PT Ecc. is higher than PT Conc. Thus for a given level of EMG, the developed force is more important in eccentric than in concentric.

References

Efficacy of linear isocinetic versus dynamic auxotonic muscle training for the shoulder – A prospective, randomised, controlled study in men

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Purpose

Rehabilitation of muscle function is an important part of therapy in overuse-syndromes and after surgery of the rotator cuff or capsule and ligaments of the shoulder joint. Thus, the knowledge of the efficacy of different training methods is necessary to optimize and to accelerate rehabilitation.

Material and methods

63 healthy men, aged 18–46 years were included in the study. Fifteen volunteers each were randomised to the three training-groups theraband, course apparatus and Moflex® R, a linear isokinetic device. The other 18 men were the control group. There was no difference between the groups concerning the age, height and body weight (ANOVA, \( p < 0.05 \)).

Every volunteer carried out a training program over six weeks, three times per week. Before and after the program a rotational (Biodex® R) and linear (Moflex® R) isokinetic test was absolved.

The difference of the values before and after training were calculated and the efficacy investigated, using a multivariate analysis of covariance.

Results

All parameters of the eccentric part of the three dimensional movement abduction / external rotation / extension shows significant differences \( (p = 0.008) \).

In relation to the theraband and the course apparatus group, the isokinetically trained group demonstrates significant and high significant improvement of the eccentric peak torque, power and performance. There is no difference of these parameters between the dynamically trained groups.

For the concentric part of the abduction / external rotation / extension there is a significant difference of the Moflex(r) group in relation to the control group.

Neither the other three dimensional, nor the two dimensional test of the rotational system evaluates a significant effect of training of one of the groups in relation to the control group.
Discussion

The conventional training methods in shoulder rehabilitation do not improve the outcome concerning muscle strength, performance and work. Therefore, a longer time period for regaining full muscle function is necessary after operative treatment in shoulder joint injuries. Slight improvements can be achieved by using the linear isokinetic training apparatus (Moflex®) especially for eccentric capacities.
Isokinetic study of primary total knee arthroplasty

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Introduction

Isokinetic evaluation of total knee arthroplasty (TKA) is poorly documented in the orthopedic literature. Only one documented study has been found \cite{1} while another is published without basic data or measurement unit \cite{2}. The clinical knee scores (HSS, KSS, . . . ) don’t take into account objective accurate and reproducible measurements of the muscular strength permitting comparison with the other knee of a patient or other prosthetic knees of different groups of patients. The current isokinetic study is performed on the AGC knee prosthesis that has shown in survivorship analysis one of the best results of the Swedish study of Knutson et al. \cite{3} and 98\% at 10 years in a study of 2001 of these prosthesis (Ritter et al., 1995).

Methods

Investigators independent of surgeons collected the data. From a series of 68 primary AGC total knee replacements (72\% posterior stabilized design; 100\% resurfaced patella) in 65 patients (91\% osteoarthritis), 49 have been evaluated. Nineteen patients were excluded: 3 deaths after release from the hospital, 3 revisions (1 infection and 2 patello-femoral pains), 5 major medical problems and 8 lost patients. Mean age is 68 years for females (75.5\%) and 65 for males (24.5\%). Prior knee surgery consists in 7 osteotomy, 5 Emslie-Maquet procedures, 2 fractures, 2 meniscectomy and 1 patellectomy. There were 75\% knees with a varus deformity (mean: 9.5\degree) and 25\% with a valgus (mean: 6.5\degree). Patients were evaluated by mean of the HSS score and the evolution of the strength of extension and flexion of the knee joint was measured with a Cybex Norm\textsuperscript{R} dynamometer. In the present paper, only the deficit of the peak torque (PT) at 60\textdegree/sec of the operated knee (expressed in percent of the PT of the unaffected knee) is presented.

Results

The average duration of the follow-up is 35 month (median 34, SD 12, min. 15, max. 59). Fifty percent were tested at 3 years or more. The mean HSS score is 86 (“excellent” result; median 92, SD 13, min. 51, max. 98). The HSS score was lesser than 60 for 4 (9\%) patients.

Percentage of isokinetic deficits (−) or gains (+) after TKA are presented in the following histograms (N = 49):

- Average deficit if 0\% for extension (median 7; SD 48, min. −64, max. +239) and 3\% for flexion (median 0, SD 29, min. −83, max. 117). As a difference of 10\% between the knees in isokinetic measurements at 60 \textdegree/sec is generally considered not significant, more than 65\% of the patients don’t present a loss of strength of the operated knee at the end of the follow-up. A poor but significant correlation is found between the strength of the two knees after TKA of one of them (r = 0.55, p < 0.001). No correlation is found between the HSS score and the percentage of deficit or gain of strength after TKA. For 22 patients comparison of the isokinetic testing was performed at 15
month and at 40 month: an evolution to more better results is observed without significant difference between the means.

Conclusion

The study demonstrates the harmlessness and the feasibility of isokinetic testing in elderly patients with osteoarthritis of the knee. The follow-up at 3 years of the AGC prosthesis indicates an excellent average HSS score and a recovery of the joint function and muscles strength equal or superior to unaffected knee for two third of the patients. A slow evolution of the performances seems to be possible beyond one year. Other numerous parameters of the study will be discussed (comparison with normal population, isokinetic work and power . . .).

References

Relationship between the health related to the quality of life and the isokinetic strength at wrist and knee

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The purpose of this research is to explore the relationship between Health related to Quality of Life (HrQol) and isokinetic strength in postmenopausal women. Forty women (55 to 80 years old) volunteered to participate in the study. The isokinetic assessment (Biodex Quick, USA) included the bilateral peak torque due to concentric contractions measured at different speeds (60, 180 and 360°/s) during the ulnar/radial deviation of the wrist and the extension/flexion of knee. The HrQol was examined by a Visual Analogic Scale (VAS) from 0 to 100% of best imaginable health status and the EuroQol 5-D questionnaire. This questionnaire explore 5 domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each domain is divided into three levels of severity corresponding to no problem, some problem and extreme problem.

The perception of health (VAS-score) was not significantly linear-correlated to any peak torque. The ANOVA did not significantly detect any difference in the mean of the ulnar/radial peak torque among the three levels of the five domains. However, the mean of peak torque during the extension and flexion of the knee at two sides and three speeds were significantly \((p < 0.05)\) different among levels in the dimensions of mobility, self-care and pain/discomfort. In addition, the flexion/extension strength showed differences \((p < 0.05)\) at 210 and 360 °/s in the domain of usual activities. The strength during the extension of the non-dominant knee was also different \((p < 0.05)\) between women who reported some problems in the anxiety/depression domain and the others.

As far as the isokinetic strength of extension and flexion of the knee is well associated to HrQol in old women, the isokinetic methodologies could be useful to assess HrQol programs.

Acknowledgement

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Proprioception and thus muscle strength measurement of the knee joint

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The influence of the posture of the head and the cervical column over extensor and flexor muscle activity is known as well as the reciprocal influence of the posture of the pelvis, the lumbar, thoracic and cervical column. Because the amount of muscle activity must influence the quality of proprioception the precondition of posture must also influence proprioception test results in case of the knee joint.

30 male volunteers (age: 20–31 a) without orthopedic problems underwent a joint angle reproduction test in a 3-dimensional measurement procedure (video-analysis) in 4 different postures: sitting, prone, standing and standing with load) with and without activation of the abdominal muscles. Half of this group (randomized) was preconditioned by a specific program of muscle exercise to improve upright posture of the trunk by coactivating abdominal, back, gluteal and hamstring muscles. The results were proved statistically (niveau of significance: \( p < 0.05 \)).

The observed 4 different posture conditions lead to different results in the angle joint reproduction test in case of the knee joint. The voluntary activation of abdominal muscle activity without preconditioning does not influence these results. However preconditioning with specific muscle exercise due to an optimized upright posture of the trunk improves the reproduction ability of the angle joint.

The differences in the testing results with the corresponding posture support the assumption that different posture conditions influence the reproduction ability of the joint angle. Because no influence can be observed by activating the abdominal muscles alone but with an optimized ability for an upright posture of the trunk in all observed positions an interaction due to extensor and flexor muscle activity like the influence of the posture of the head and the cervical spine seems to be possible.

Heterogenous results in proprioception testing can be explained not only by different testing procedures but also by different posture conditions and preconditions. Because the quality of proprioception must influence the quality of muscle activation, conditions and preconditions of the posture of the trunk must also influence results in testing muscle strength.
Isokinetic strength and gait parameters in multiple sclerosis

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Introduction

Correlations between strength and gait parameters have been studied for a long time in hemiplegic patients but no study was yet performed to extend these results to multiple sclerosis (MS). Bilateral achievements so that sensory and cerebellar deficiencies that frequently occur in MS may change the usual relation related between motor function and gait parameters. This study was performed to evaluate strength parameters in MS and their relation to gait hability with respect to different clinical aspects.

Methods

27 patients with definite MS were included in this study. All were able to walk without aid (EDSS < 6). Two investigations were performed:

– Isokinetic evaluation of strength at knee level (flexion/extension at 60°/sec)

– Gait parameters registration with Locometre device, including average speed, frequency and step length.

An Anova statistical evaluation was performed to correlate strength and gait parameters with respect to 4 clinical forms (spastic, spastic-ataxic, spastic-cerebellar, spastic-ataxic-cerebellar).

Results

Strength of quadriceps and hamstring are bilaterally reduced in MS.

When considering all cases, hamstring strength is positively related to gait velocity (frequency and step length) when quadriceps strength is not, both at comfortable and higher speed.

When considering the different clinical aspects of MS, quadriceps strength is related to gait parameters in spastic-ataxic patients and unrelated in other forms.

Discussion

Hamstring deficiency appear to be the most predictive strength parameter in estimating gait hability in multiple sclerosis. Quadriceps strength may be critical in some clinical forms with sensory loss. These results may help to define the modalities of rehabilitation with strengthening aimed to improve gait function in multiple sclerosis.
Normal values of con- and excentric peak torque, work and performance of modified pnf-patierns of the shoulder

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Purpose

The study evaluates normal values of peak torque, work and performance of three-dimensional, physiological movements of the shoulder in concentric and eccentric mode using a linear isokinetic device (Moflex \(^\text{R}\)) to get a base for diagnostic and therapy in rehabilitation.

Material and methods

66 healthy volunteers, aged 18 to 46 (mean 29.7 ± 7.2 a) years, performed two tests of shoulder exercises with ten repetitions using a linear isokinetic device with a velocity of 0.4 m/s. The first movement extend a ROM concentrically from 0\(^\circ\) to 90\(^\circ\) of abduction, −70\(^\circ\) to 90\(^\circ\) of rotation and from 20\(^\circ\) to 0\(^\circ\) of flexion and turning back eccentrically. The second exercise was reversed to the first. The parameters peak torque, total work and performance were evaluated for each side, additional the relationship of dominant to non-dominant, of concentric to eccentric and movement I (abduction/external rotation/extension) to movement II (adduction/internal rotation/flexion) statistically analysed (SSPS \(^\text{R}\)).

Results

All parameters are standard distributed, the test is reliable. The mean peak torque of exercise I of the dominant arm is 181.9 N concentrically, 192.3 N eccentrically, work obtains concentrically 897.7 J, eccentrically 677.1 J, performance 45.7 W, respectively 31.5 W. Exercise II reaches 204.5 N at concentric, 213.5 N at eccentric peak torque. The values of work are 1085.6 J and 875.6 J, of performance 55.4 W and 40.3 W. Motion I is statistically stronger on the dominant arm, motion II differs not (\(p<0.05\)). The combination of adduction, internal rotation and flexion is stronger than the motion of abduction, external rotation and extension. Peak torque is eccentrically greater, work and performance concentrically (\(p<0.05\)).

Conclusions

Testing three dimensional shoulder movements is reliable and generates standard distributed values. The evaluated results are a basic for diagnosis of shoulder complaints in overuse syndromes and for planning and controlling rehabilitation after shoulder surgery.
Isokinetics as a tool to assess instantaneous passive stiffness of spastic ankle joint

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\textsuperscript{c}UMR CNRS 6600, Université de Technologie de Compiègne, Compiègne, France
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Introduction

Changes in the mechanical properties of the musculo-tendino-articular complex are thought to be at least partly, responsible for increased resistance to passive dorsiflexion of the ankle in spastic patients [1,2]. Therefore, the present study was designed to develop a method to quantify the passive stiffness of the ankle. This was done by measuring torque and angle obtained with an isokinetic device during passive rotation of the ankle in the absence of significant muscle activation, as judged from EMG recording [3]. The method proposed was validated by comparing stiffness measurements of normal healthy subjects with those obtained for spastic hemiplegic patients during dorsiflexions imposed at different velocities.

Materials and methods

Eleven spastic hemiplegic patients (Spastic group) and eleven healthy subjects (Control group), matched for age, were evaluated on the Cybex\textsuperscript{R} Norm\textsuperscript{TM} isokinetic tool in a sitting position, with knee extended. Ankle joint was moved passively from 35 degrees of plantarflexion to 5 degrees of dorsiflexion. Four trials were performed at each velocity tested: 10, 60, 90 and 120 deg/sec. Surface EMG with on-site preamplification was used to monitor the activities of the medial and lateral gastrocnemius, the soleus and tibialis anterior muscles. Any trial with an obvious associated EMG activity was discarded. Raw resistive torque, corrected a posteriori for gravitational effect, and ankle angle data were analog-to-digital converted and analyzed using specific softwares. Analysis consisted first to define, within the full range of motion, the portion where the movement velocity was really that prescribed by the operator, i.e. free of artifacts due to acceleration or deceleration. Corresponding extracted torque and angle values were then fitted to a fourth order polynomial equation to generate a torque versus displacement curve for each velocity tested. Finally, instantaneous stiffness was calculated using the derivative of the polynomial equation to describe degree per degree the slope of the curve. Repeated measures ANOVA and Tukey post-hoc tests were used for comparisons between Spastic and Control groups (\(\alpha\) set at 0.05).

Results

Passive stiffness values were almost always higher for the spastic group. The differences between stiffness values for control and spastic subjects were all the more important as the velocity of the imposed movement was higher. (see Fig. 1 for mean results obtained at lowest and highest stretch velocity).
Fig. 1. Mean values ($N = 11$) of ankle passive stiffness (in N.m/deg) for the Spastic and Control groups at 10 and 120 deg/sec.

**Discussion**

The method presented here allows the calculation of an instantaneous (i.e. degree-per-degree) passive stiffness which is found more important for the hemiplegic spastic group than for the control group. Sensitivity of the stiffness to the stretch velocity has been observed for spastic patients. These results indicate an impairment of the musculo-articular system to develop a correct tensile response when stretched in passive conditions. These changes in visco-elastic behaviour of the musculo-articular system in spastic subjects may result from structural adaptations of the spastic joint.

**References**

Poster Abstracts
A new way of active control of posture in apparatus based muscle testing exercise

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Posture and its control has been detected as one of the most important aspects in the construction of apparatus for muscle exercise and muscle testing with regard to effectiveness, overloading and reliability. Two ways were commonly used to guarantee defined posture: An anatomical surface of the upholstery of the back rest and a blocking of unwanted postural deviation by the use of straps or adjustable pads and barriers both with the disadvantage of possible negative interactions with individual differences of the back surface and moreover with the muscle performance. Therefore this study wants to show a new way how to avoid these disadvantages.

A postural biofeedback system was developed due to posture control without any passive, mechanical fixation in apparatus based muscle exercise and muscle testing. The concept of this system is based on a sensory record of the posture of the vertebral column by mechanical sensors. These sensors were placed especially in the area of the lumbar and thoracic spine with the possibility of individual adaptation. In addition results of muscle activity and muscle strength can be correlated with a defined and reproducibly active controlled posture of the vertebral column. Muscle strength of 10 male sports students aged 21–24 was measured with and without this control and with corresponding fixation procedures in a test and retest procedure.

The results show highly significant differences in result variation after the use of postural biofeedback system. The strength test results under the use of this biofeedback system were significantly reduced in comparison to non-controlled conditions.

The reduced variation of the results in muscle strength under active and biofeedback supported control identify this concept of muscle strength measurement as a more valid testing procedure. Therefore active control of deviation of the vertebral seems to be of great importance for reliable muscle strength measurements. The significantly reduced values of muscle strength under active control of the posture may lead to the assumption that muscle exercise based on this concept may be less effective. However any conditions of bipedal standing and motion does not include passive back control so that neither testing nor exercise under these condition can simulate physiological demands to muscle strength, so that measurement results received under the use of this new method seem to be more relevant according to effectiveness and medical importance.
Contribution in the increase of the muscular force by mechanical stimulation

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Introduction

This work is a contribution in the improvement to the muscular force by a mechanical stimulation of the stretch reflex. We will show, by using a simulation model, the efficiency of this technique on the increase of the muscular force of quadriceps during a training session on an isokinetic machine.

Method

During a contraction, several abrupt stretches of the muscle are used to provide consecutive activation of the reflex. In this way, the muscle is solicited with supplementary contractions, which are added to the basic contraction, to increase the developed force [1]. Hence, during an isokinetic movement which is realised with a predetermined constant velocity, it is possible to provoke the myotatic reflex in two different ways.

– Stimulation by abrupt inversion of the movement direction,
– Stimulation by an abrupt advance of the movement in the original direction and then by an inversion of the movement direction.

To quantify and put in evidence the efficiency of the reflex on the muscular intensification, we use the simulation model including:

– the muscle model given by Zajac [2,3], which generates, from the activation and the muscle length, the developed muscular force according to the articular angle ($q$) of the knee.
– the model of an isokinetic machine together with the adequate control laws for isokinetic movements [4,5],
– the Stretch reflex activation model generating the stimuli during the movement and controlling the stimulation’s frequency and amplitude.

Results and comments

The simulation results depicted in Fig. 3 illustrate the influence of the stretch reflex stimulation on the force developed by the muscle in isokinetic mode. The results are compared with those obtained using the same training mode, but without the activation of the stretch reflex loop stimulation. This figure shows an improvement of the muscular force for various stimulation frequencies ranging from 5 to 50 Hz and for amplitudes from 1 to 5 degrees. In this study, we have presented a modelling concerning the application of the stretch reflex during the muscular intensification. The obtained results showed the efficiency of this technique on the increase of the developed force during an isokinetic movement. Our current works concern the establishment of this technique on Multi-Iso, an isokinetic machine developed by our laboratory in association with the Myosoft company.

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References

Eccentric vs concentric isokinetic evaluation of trunk extensors in standing position

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Little research concerning eccentric isokinetic back muscles activity has been performed, and all was done in a sitting position and with reciprocal contractions [1–3]. The aim of our study was to describe the eccentric and concentric isokinetic strength profile of the trunk extensors of males in standing position.

30 healthy males (age 29 ± 5 yr, height 182 ± 5 cm, weight 78 ± 7 kg) without any history of back disorder took part in the study. A Cybex® Norm™ isokinetic machine with TMC accessory was used and the subjects stood on footplates. The height of the dynamometer axis corresponded to the horizontal axis L5-S1 and movement was performed from 0° (comfortable upright position) to 75°.

A 10 minutes warm-up preceded the testing protocol. In the concentric mode (Conc) extensors contracted maximally during the extension movement and flexion was done passively. In the eccentric mode (Ecc) the subjects started in the upright position and, without any pre-load contraction, resist the powered flexion movement by a maximal trunk extensors contraction throughout the range of motion. For the reverse (extension) the movement was done with the lowest muscle contraction intensity and also with assistance of the operator. For trials and tests, the angular velocity was 30°·s⁻¹ and repetitions were 3. In order to avoid a sequence effect, 15 subjects started with the eccentric mode test, and 15 others with the concentric one. Rest time between two modes was 120 seconds. No gravity correction was conducted.

We analysed Peak Torque (PT), Best Work (BW) and Average Power (AP) of the Extensors and for the two modes (Table 1). The differences were identified by paired t. tests. Significance was set at the \( p < 0.0001 \) level. Ratios for the eccentric (Ecc) to concentric (Conc) were calculated (Table 2). All the eccentric parameters were higher than the concentric parameters (\( p < 0.001 \)). Average eccentric to concentric (Ecc/Conc) ratios ranged from 1.29 to 1.53. The angle of PT is for concentric and eccentric, respectively, 52 ± 11° and 41 ± 15°.

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<th>Data summary (mean ± SD)</th>
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<td></td>
<td>PT (N·m)</td>
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<tr>
<td>Conc</td>
<td>322 ± 56</td>
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<td>Ecc</td>
<td>412 ± 62</td>
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<tr>
<th>Table 2</th>
<th>Ratio Ecc/Conc (mean ± SD)</th>
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<tr>
<td></td>
<td>PT</td>
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<td></td>
<td>1.29 ± 0.14</td>
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Studies which had been performed using back isokinetic eccentric tests were done through different ranges of motion, with reciprocal movements and different protocols (angular velocity, number of repetitions, preload etc. . . .). The Ecc/Conc ratios ranged from 1.22 to 2.06. Our findings showed that eccentric PT of extensors tested in standing position was 30% higher than concentric one. Power which represents the capability to maintain contraction all over...
the range has the more higher Ecc/Conc ratio. In many functional tasks hip and trunk muscles are biomechanically linked and they have to be associated in testing. Our Ecc-Conc isokinetic evaluation concerns only the extensors and gives us some details on neurophysiological pattern of muscles which are often involved in back disorders. After testing, feelings of all subjects were quite the same: compared to concentric mode eccentric was done with safety. On the other hand, DOMS and stiffness were present two days afterwards for a large number of subjects. Our reference data can help therapists to build up sub-maximal strength protocols (percentage of max) and to control the effects of back active rehabilitation programs. In terms of strengthening, eccentric back activation is often better than concentric one [4]. We suggest also to stretch back and pelvis muscles after each eccentric session.

References

Influence of strength performance disorders on hamstring strain recurrence

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Hamstring strains are among the most common muscle injuries in “speed athletes”. Owing to the high rate of reinjury and persistent complaints when returning to athletic activities, most authors have emphasized the necessity of clarifying etiological factors. We started with the following hypothesis: One reason hamstring injuries have a tendency to relapse may be that the athlete is not fully rehabilitated when resuming practice and thus trains or competes in a position of muscle weakness and agonist-antagonist imbalances. The purpose of this study was twofold: First, to determine the frequency of strength disorders in the context of recurrent strains and complaints after initial hamstring injuries and secondly, to assess the effectiveness of correcting muscle performance on sport practice conditions.

Twenty-six high level athletes with history of hamstring injury participated in the study. Each sought medical consultation for a recurring pattern of injury or a prolonged hamstring pain syndrome (persistent problems as discomfort and inhibition during athletic activity). They were examined through concentric (60°.s⁻¹ and 240°.s⁻¹ for both flexor and quadriceps muscles) and eccentric (30°.s⁻¹ and 120°.s⁻¹ for flexors) isokinetic assessment using a Kintrex 500 dynamometer. The result analysis concerned peak torque (PT) bilateral asymmetries, conventional flexors/quadriceps (Fl/Q) concentric ratio and an original mixed ratio (Fl_{ecc}/Q_{conc}) that associated flexors’ eccentric performance (at 30°.s⁻¹) and concentric action of the quadriceps (at 240°.s⁻¹). Isokinetic deficiency was determined using statistically selected cutoffs [1]. Each selected patient sustained an immediate rehabilitative program, including hamstring isokinetic strengthening individually established from isokinetic profile. The corrected muscular status corresponded to less than 5% of deficit through bilateral comparison and concentric and mixed ratio respectively superior to 0.57 and 0.98 [?]. Subjects were followed for 12 months from the end of treatment: interest concerned new history of hamstring injury and evaluation of pain and discomfort (visual analogue scale) during training and/or competitive situation.

Eighteen (69%) athletes were found to have strength deficits, related to PT bilateral differences and/or flexors/quadriceps (Fl/Q) ratios. The discriminating character of the eccentric trial was demonstrated, combining a preferential eccentric PT deficit and a significant reduction of the mixed Fl_{ecc}/Q_{conc} ratio. These 18 unbalanced athletes were included in the rehabilitative program. Treatment length was from 10 to 30 sessions, permitting isokinetic parameter normalization in 17/18 subjects. After return to athletics, none of them sustained clinically diagnosed hamstring muscle re-injury; subjective intensity of pain and discomfort during sport situation were significantly (p < 0.001) reduced and they all recovered to their prior level of competition.

No consensus exits for rehabilitation of hamstring muscle strain and we suggest that classical rehabilitative treatment regularly neglects the final therapeutic phase, especially muscular reinforcement. We believe this represents a lack of understanding of the mechanism of injury and the factors that contribute to hamstring stain. Consequently, as a complement to the usual recuperation of the flexibility quality, amelioration of muscle strength and correction of agonist-antagonist imbalances would also represent a primary goal in the rehabilitation process. We recommend the inclusion of eccentric exercises, at elongation position of the hamstring muscles. By using, in particular, a mixed ratio (Fl_{ecc}/Q_{conc}), indicator of muscular imbalance and risk predictor of further injury, isokinetic assessment must contribute to determine the most opportune moment for the athlete to return to the competitive situation. In conclusion, the major findings in this study were as follows: 1) persistence of muscle weakness and imbalance may
give rise to recurrent hamstring injuries and complaints; 2) classical rehabilitation processes may be improved by initiating individualized strengthening based on noted deficits (particularly in eccentric); 3) compensating training contributes to a decrease in symptoms on return to activity.

Reference

The development of 1 repetition maximum (1RM) depending on the training frequency during a hypertrophy training program with high performance athletes

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In a lot of sports one repetition maximum represents the basic element of high performance. Besides the neuronal activation of the muscle, which can be improved in training periods with maximal contractions, muscle mass represents the most important factor that – in long term – influences maximum strength. To achieve the optimum in the development of muscle mass it is very important to provide the muscle tissue with sufficient time of regeneration. One of the consequences is that, besides set and repetition number, the training frequency poses a main question concerning the optimization and planning of programs to develop muscle mass. The major goal of this study was to find evidence of a training frequency that promises optimum success in the proliferation of muscle mass.

33 male subjects with several years of training experience participated in this study of strength training. The subjects were divided into three groups of 11 persons each, who had to go through a hypertrophy training program for arm bends with a frequency of one (G1: 1RM 59.7 ± 8.1 kg; age 29.9 ± 4.5 years; weight 86.6 ± 3.3 kg), two (G2: 1RM 57.2 ± 6.2 kg; age 29.0 ± 5.1 years; weight 85.5 ± 5.5 kg) and three (G3: 1RM 54.8 ± 6.4 kg; age 26.3 ± 4.7 years; weight 89.3 ± 7.0 kg) training sessions per week for up to eight weeks altogether. The training programme consisted of five sets with a three minute rest between each. Every set was carried out to the point of muscle failure. The weights to be lifted were chosen in such a manner that a minimum of eight and a maximum of twelve repetitions per set could be carried out. If the test person was able to fullfill twelve repetitions, more weight was added in the next training session. To provide the training with a greater variety, four different types of exercise were selected. Two of them were exercised at each workout: day 1: three sets of barbell curls while standing + two sets of dumbbell curls sitting on an incline bench; day 2: three sets of dumbbell curls while sitting + two sets of preacher curls. Both training units were carried out with a continuous alternation of those types of exercise. The 1RM was established through the preacher curl exercise, which had to be carried out with a purely concentric movement (starting position: 170° elbow angle). The 1RM was tested: before starting the training session (T1), after four weeks time (T2), three days (T3) and finally thirteen days (T4) after the last training session.

The statistical handling of the data consisted of an analysis of variance (with a repetition of the measurements) and the Scheffé-test ($p \leq 0.05$) as a post-hoc test to check the differences between the three groups with respect to the development of maximum strength.

In group G1 the dynamic maximum increased from 59.7 ± 8.1 kg up to 61.0 ± 8.2 kg; in group G2 it increased from 57.2 ± 6.2 kg up to 61.3 ± 6.4 kg; and finally in group G3 it increased from 54.8 ± 6.4 kg up to 61.6 ± 6.1 kg. In the course of this study there was a significant increase in dynamic strength in group G2 and G3 but not in G1. From the first to the last testing there was a change in the dynamic strength of 2.7% in group G1, 7.3% in group G2 and 12.8% in group G3. The further statistical analysis presented a significant difference between the groups G1 and G3, but not for the groups G1 and G2, G2 and G3 respectively.

These results show that for people with high training experience one training stimulus per week is not enough to
achieve a significant increase of strength, whereas training two or three times a week leads to a noticeably larger increase of the dynamic maximum strength and is therefore to be preferred. Training three times a week results in the maximum proportional growth, yet the additional increase of strength might justify the required training effort for a period of eight weeks. With respect to the relation of expenditure and benefit and the fact that in a lot of sports other training contents have to be maintained – in long term – a training frequency of two training sessions a week seem to be optimal.
Influence of physiotherapy and insoles on isokinetic peak torque of the ankle and EMG of lower leg muscles in runners with unilateral achilles tendon complaints

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Achilles tendinitis is one of the most prevalent factors of complaints in running. Up to now etiological factors and therapy strategies are not perfectly understood. Concerning aetiology malalignments and muscular dysbalances are cited among others. Treatment is therefore often based on physiotherapy and orthopaedic insoles. Subjective improvement of complaints after eccentric training regimen could have been shown without measurable proof [1,2]. The purpose was thus to investigate objective differences in EMG pattern and isokinetic peak torque after 4 weeks of physiotherapy with special focus on eccentric training and treatment with individual orthopaedic insoles.

29 male runners with unilateral Achilles tendon complaints included had to be free of other injuries and untreated during the last 6 months. The (injury typical) mean age of subjects was 39 (± 6) years. Weekly mileage was 51 km (± 21), with a minimum of 32 km. Initially, differences between healthy (H) and injured (I) leg as well as between isometric, concentric (60 and 180°/s) [c60 and c180] and eccentric (60°/s) [ecc] contraction were evaluated using isokinetic measurements (LIDO-ACTIVE, Loredan Inc.) and surface EMG (MYOSYSTEM 2008, Noraxon, 10 channels) in ankle plantar flexion. EMG of Mm. gastrocnemii medialis (GM) and lateralis (GL) and M. soleus (SOL) were rectified, smoothed (root mean square of 50) and normalized to MVC. Averaging of 5 cycles was made for isokinetic and EMG data. MVC was chosen by the highest peak torque value at three different positions in ROM. All runners were randomised to the treatment groups “Control” (CO, n = 10), “Insoles” (IS, n = 10) and “Physiotherapy” (PT, n = 9). Intervention effects were tested in the same protocol after 4 weeks. Statistical analysis was made descriptively and by multifactoral repeated measures ANOVA with the factors “therapy group”, “contraction mode” and “leg”.

We found no statistically significant differences at the initial measurements between H and I neither in torque nor in EMG quantities (p > 0.05). The comparison of contraction modes shows EMG mean values over 100% of MVC in c60 for all muscles, whereas torque data reveals a lower peak torque compared to ecc. Eccentric contraction leads to higher peak torque and lower EMG values (p < 0.05, Fig. 1). Evaluation of therapy groups show no changes due to treatment in none of the evaluated quantities (p > 0.05). H and I also show no differences after intervention. The relation of contraction modes stays stable.

The fact that eccentric contraction leads to higher peak torque and lower EMG values than isometric contraction is according to healthy individuals and other muscle groups due to passive elasticity forces [3,4]. Efficacy of the various forms of therapy cannot be demonstrated on the basis of isokinetic measurements alone. Possible improvement of complaints is based on a complex adaptation and can not be shown in single joint motion.
Fig. 1. EMG mean values in different contraction modes (in % of MVC).

Fig. 2. EMG values (in % of MVC) for M. soleus in different groups (CO, PT) of healthy (H) and injured (I) leg before (1) and after (2) intervention.

References

Muscular endurance of the lower leg muscles in runners with unilateral achilles tendon complaints

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Achilles tendon complaints are frequent in runners. This injury occurs very often only unilaterally. One possible reason might be differences in muscular capacity between dominant and non-dominant leg. As a result of possible deficits of the weaker leg, compensation for various stresses acting on the body throughout the running movement is reduced. Especially different muscular endurance may play a role in running specific injury predisposition. It is still to question if strength capacities differ intraindividually between healthy and injured extremities. The purpose of this study was therefore to analyse muscular endurance capacity in runners with unilateral Achilles tendon complaints.

Overall, 60 runners with unilateral Achilles tendon complaints (ATC) were enrolled in the study. The average age was 39 (± 6) and the weekly mileage was 51 km (± 21), where a minimum of at least 32 km was required. Isokinetic force measurements (LIDO-ACTIVE, Loredan Inc.) were taken in plantar flexion and dorsal extension at the ankle for both legs. All subject had to perform a concentric (180°/s) and an eccentric (60°/s) strength test lasting one minute for each movement [4]. It was asked to perform all tests at maximum subjective exertion. A quotient Q was calculated to quantify muscular fatigue (MF): The arithmetic mean of the torque of the last 5 repetitions was divided by the arithmetic mean of the first 5 repetitions of each test [2]. For the two modes of exercise and the two movements 4 MF-quotients were calculated: \( Q_{PF_{con}} \) (plantar flexion concentric), \( Q_{PF_{ecc}} \) (plantar flexion eccentric), \( Q_{DE_{con}} \) (dorsal extension concentric) and \( Q_{DE_{ecc}} \) (dorsal extension eccentric). Statistical analysis was made by descriptive statistics (mean, standard deviation, 95%-confidence intervals). Possible side differences between healthy and injured leg were analysed by means of univariate one-way ANOVA (\( \alpha = 0.05 \)).

The initial analysis of side differences between healthy and injured leg proved that there are no differences for all calculated quotients. Fig1 shows exemplary results for \( Q_{PF_{ecc}} \). Comparison of exercise modes revealed higher peak torques in eccentric than in concentric mode. Torque generation was also higher in plantar flexion than in dorsal extension. Concerning muscular fatigue, eccentric quotients (\( Q_{PF_{ecc}}, Q_{DE_{ecc}} \)) were higher than concentric quotients (\( Q_{PF_{con}}, Q_{DE_{con}} \)). This means less fatigue under eccentric exercise. Fatiguing effects in plantar flexion were lower than in dorsal extension (see Tab1). The values above 1 for \( Q_{PF_{ecc}} \) indicate no effects of fatigue in this mode.

\[
\begin{align*}
\text{Q\_PF_{ecc}}
\end{align*}
\]

Fig. 1. Comparison of healthy and injured leg.
No effects on force abilities in the injured leg (due to pathology or pain) in runners with ATC could be shown. Higher standard deviations in the injured leg (Fig. 1) seems to reflect more variability in the force production of the injured leg. It seems that muscular recruitment follows the same pattern for both sides of the body. The main result of less fatigue under eccentric exercise corresponds to results of previous studies on healthy subjects [1,3]. The conflicting result of no fatigue in eccentric contraction in plantar flexion ($Q_{PFecc}$) might be due to learning effects of the subjects along the test or possibly a more motivated state towards the end of the test. We conclude that the general postulation of strength training for patients with ATC to prevent muscular dysbalances has to be challenged. Neuromuscular training to enhance coordination has to be the focus in the prevention and rehabilitation of ATC rather than strength training alone. If strength training is necessary, eccentric work has the advantage of less fatigue and higher force production.

### Table 1

<table>
<thead>
<tr>
<th>MF-quotient</th>
<th>Healthy</th>
<th>Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{PFcon}$</td>
<td>0.70 ± 0.21</td>
<td>0.73 ± 0.16</td>
</tr>
<tr>
<td>$Q_{PFecc}$</td>
<td>1.04 ± 0.15</td>
<td>1.05 ± 0.17</td>
</tr>
<tr>
<td>$Q_{DEcon}$</td>
<td>0.41 ± 0.11</td>
<td>0.42 ± 0.14</td>
</tr>
<tr>
<td>$Q_{DEecc}$</td>
<td>0.85 ± 0.16</td>
<td>0.82 ± 0.15</td>
</tr>
</tbody>
</table>

References

Balance training in male and female judokas: Gain in strength

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A preliminary study showed a gain in strength after balance training in non-specifically trained men and women [1]. The observed gain in strength raised the question as to how far balance training might lead to a gain and strength in top level athletes requiring strength and balance.

20 top level judokas, 10 male and 10 female agreed to take part in balance training for six weeks, three times per week for thirty minutes.

Men: 28 ± 5.1 years, 180 ± 5.6 cm, 82 ± 17 kg, experience 16 ± 5.8 years.
Women: 24 ± 6.2 years, 166 ± 5.6 cm, 60 ± 6.9 kg, experience 8.4 ± 6.9 years.

Balance training consisted of both-leg balance exercises and one-leg exercises, which stressed the knee extensors and knee flexors for 6 minutes each, altogether for 24 minutes per unit. For the exercises rolling board, pigtop, soft mattress and large rubberball were used. The training was preceded by warming up on a pedalo for 6 minutes. Prior training balance time was measured by balancing on a vertical rim. The two-leg balance was measured on a stabilometer adding the number of touchdowns right and left within 30 s. Maximal strength was tested on an isokinetic system (Lido active) with 60°/s in concentric and eccentric mode, at 120°/s concentric and at 0°/s isometrically flexors and extensors for both legs separately.

The flexor strength increased at 60°/s in concentric mode by 16% left and 21% right in men and 23% left and 35% right in women; for the eccentric mode, 17 and 21% and 15 and 22%, for the extensors in concentric mode at 60°/s 20 and 20% and 30 and 28% and in the eccentric mode 22 and 23%, and 25 and 26%; for the flexors at 120°/s 19 and 24%, and 27 and 23% and for the extensors 15 and 18% and 25% and 45% and for the flexors 18 and 40% and 43% and 45% and for the extensors 27 and 36% and 40 and 37%. One leg standing improved in men left by 86%, right by 151% and in women left by 109% and right 157%. The number of touchdowns went down by 25% in men and by 23% in women.

Balance training increases the strength of knee-extensors and flexors in male and female in judokas comparably; the women reached a higher gain at 60°/s in the concentric mode and for the extensors at 120°/s. Both-leg balance improved similarly and one leg-standing right more than left in both groups. The most important result of the present study is the gain in strength in a high level sport by balance training alone. In an earlier study we showed that strength training failed to reach a higher gain in strength than strength training of the same amount of time [2]. The remarkable gain in one-leg standing balance is of great importance for judokas, since the fighting position sets off in one-leg standing, balance training seems to be more efficient than strength training.

References
Influence of anesthesia on isokinetic muscle performance in patients with impingement syndrome

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Muscular imbalance of the shoulder is frequently evoked as an etiological factor in impingement syndrome. Leroux et al. \cite{1} demonstrated a significant reduction of internal rotator strength values in involved and uninvolved shoulders of patients with impingement comparatively with a healthy control group. As for the Rupp et al. \cite{2} study, external rotators / internal rotators peak torque (PT) ratio (ER/IR) was significantly lower in swimmers with shoulder conflict than in sedentary controls; in that comparative study, competitive swimmers produced significantly higher PT during internal rotation. Some authors have acknowledged the potential role of pain in the etiology of shoulder muscle weakness, but only few of them have established a such connection, and results remain contradictory.

To verify a possible nociceptive influence on shoulder strength performances, seven patients (2 women, 5 men, average age of 43.7 years) with unilateral impingement syndrome benefited from bilateral isokinetic shoulder evaluation before and after intrabursal injection of local anesthetic into the pathologic shoulder. Performances of abductors (ABD), adductors (ADD), internal and external rotators were measured on a Cybex Norm dynamometer. Using maximum concentric contractions at 2 angular velocities (60°/s and 180°/s or 60°/s and 240°/s, respectively for ABD-ADD and ER-IR assessment), PT (in N.m), body weight normalized PT (in N.m.kg\textsuperscript{-1}) and agonist/antagonist ratios were obtained. Goniometric measurements provided passive range of motion (ROM). Lying supine, subjects performed shoulder internal / external rotations in 90° of abduction in the frontal plane. In order to realize valid test on ABD-ADD, we have proposed an original protocol: subject in a lying lateral position, arm in the frontal plane, and a ROM limited to 90° of abduction. Then, all patients received a sub-acromial injection of 10 cc Marcaine (0.5%) plus 1 cc Solumedrol 40 mg; 1 hour later, the complete testing procedure was repeated for both sides.

Before injection, ABD, ADD and ER of the injured side were significantly weaker in comparison with contralateral healthy muscles. No significant modification was noted for the second evaluation of the healthy shoulder. Anesthesia injection provoked, for 4/7 patients a marked reduction of pain, evaluated by mean of a visual analogue scale (VAS); all patients were characterized by increase in passive goniometric ROM though we used the same ROM for both isokinetic assessments. No significant PT increase was observed in the injured side, although all strength measurements improved. For example, the ADD strength difference between involved and uninvolved sides reached 22% before and 9% after injection. Furthermore, after pain block, only the mean relative PT of ER remained significantly reduced ($p = 0.019$) in comparison with the contralateral side. No significant interaction was found between strength improvement and pain relief.

Most authors demonstrated significant increases in ABD and ER strength after the block. Our study suggested that block injection does not authorize significant increase in isokinetic strength parameters even if moderate improvements were observed. ER strength deficit associated with ER/IR reduction measured through the second assessment conditions could represent an important factor in the etiology. Pain has not an important effect on isokinetic muscle performances. Nevertheless, a larger group of patients would be needed to validate the conclusion.
References

Differences between inverse dynamics and maximal isometric moments of force for the knee and ankle joints on elite sprinters

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Introduction

The purpose of our study was to compare the maximal knee and ankle joints moment of force produced under isokinetic and isometric tests on a dynamometer with the ones obtained on unconstrained dynamic situations, using the inverse dynamics approach. The dynamic situations wore the acceleration phase of the Sprint Start and Drop Jump exercises.

Methods

Ten elite sprinters (height 1.761 ± 0.042 m, body mass 73.7 ± 5.1 kg, thigh length 0.433 ± 0.020 m and shank length 0.395 ± 0.018 m) performed 6 Drop Jump exercises from a height of 70 cm and 6 sprint starts from blocks. The second step after start and the drop touch down were performed over a Kistler FP, ground reaction forces (GRF) were recorded at 1 KHz. The trial where the maximal net horizontal impulse was achieved was selected for analysis. Simultaneously, 2D kinematic data of the ankle, knee, hip and shoulder joints were calculated (120 Hz). After a residual analysis of joint landmarks (Winter 1990) coordinates were filtered with a 10 Hz Butterworth 4th order, 0 phase lag low pass filter. A four-segment rigid body link system was constructed with: foot, shank, thigh and HAT (head, arms and trunk). Using an inverse dynamics approach the net joint forces and moments of force (Mf) of ankle, knee and hip were calculated. The Mf results wore corrected considering the effect of the biarticular muscles as proposed by Prilutsky and Zatsiorsky [1]. Individual muscle force was estimated using muscle moment arm and rate of muscle length change of thigh and shank muscles determined using Visser et al. [2] regression equations. The same approach was used for the in order to evaluate a drop jump from a height of 70 cm. The same athletes were tested, for the ankle and knee, joints in concentric isokinetic conditions at 30°/s and also on isometric condition, considering the joint angle at witch the maximal isokinetic moment of force was obtained.

Results

The maximal values for the concentric period of the drop jump exercise and for the support phase of the sprint start exceeds the ones obtained on both isokinetic and isometric conditions, being these differences statistically significant (Anova).

The mechanical energy transferred through the biarticular muscles could be calculated integrating over time the transfer power curves for the sprint start and the drop jump exercises [1]. The energy transferred by GAS from knee to ankle was 22.10 ± 3.6 J (23.6 ± 7.3% of net ankle joint work).
Table 1
Average results for the knee and ankle max. moment of force on a isometric tests on the biodex system3 machine, and for maximum knee extension moments during the push-off phase of the second support phase after sprint start from blocks and Drp jump exercises from 70 cm height. The Inverse dynamics moments of force were obtained during initial concentric contraction of plantar flexors and knee extensors

<table>
<thead>
<tr>
<th>Isometric Mf (Nm)</th>
<th>Average results ($N=10$)</th>
<th>Inverse dynamics Sprint Start (Nm)</th>
<th>Inverse dynamics Drop Jump 70 (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee extension</td>
<td>279.4 ± 43.4</td>
<td>296.1 ± 21.3 *</td>
<td>353.2 ± 43.2 **</td>
</tr>
<tr>
<td>Plantar Flexion</td>
<td>172.1 ± 28.7</td>
<td>195.7 ± 15.1 *</td>
<td>261.1 ± 33.1 **</td>
</tr>
</tbody>
</table>

* Differences significant for a $P<0.02$.
** Differences significant for a $P<0.01$.

Discussion

The biarticular muscles appear to have an important role in transferring energy from the proximal joint, where the muscles with larger volume are located, to the distal joints. The distal limbs have muscles, with shorter fibres and larger tendons that are suitable for fast contracting velocities, these characteristics associated with the transfer mechanism of the biarticular muscles allow for a efficient high power output at the distal joints. Additionally, the analysis of the force-velocity curve (Fm-Voi) show a clear concave shape of the curve that contrasts with the traditional (Fm-Voi) obtained on studies in vitro with isolated muscle our muscle fibbers. The differences obtained have important meaning, for instance the maximal power in isolated muscles was obtained at 30% of max contraction velocity while in freely moving situation max power could be obtained at 60% of maximal force and at 80% of maximal contraction velocity. This force-velocity relation found in actual movements studies appears to be connected with elastic behaviour of the muscle-tendon complex. The ability of maintaining high levels of stretch reflex during the RIA phase, a strategy of the neuromuscular system to reset the motoneurons in order to produce a triggered and synchronised activation of all unit, simultaneously with the ground contact. The mechanism listed should be responsible for the higher moments of force obtained on the inverse dynamics analysis of actual dynamical movements.

References