Abstracts

Technical Aspects

Physiological consequences of strenuous concentric and eccentric isokinetic exercises

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Eccentric exercises are increasingly prescribed in the assessment and rehabilitation of musculo-skeletal injuries and disorders [1,2]. Under experimental conditions, researchers have also used isokinetic tools for investigating delayed onset muscle soreness (DOMS) induced by repeated eccentric bouts of contraction [3].

A better knowledge of the cardiovascular and metabolic response to maximal isokinetic exercise may be useful for an adequate and safe prescription of eccentric protocols. This study aimed to compare the fatigue pattern and some physiological consequences of strenuous concentric (CON) versus eccentric (ECC) isokinetic exercises.

Twelve healthy male subjects (24 ± 3 years old; 70 ± 5 kg; 180 ± 6 cm) not especially trained volunteered to participate in the experimental protocol. At two different sessions separated by two weeks, subjects performed, in a randomly assigned order, either CON or ECC isokinetic contractions on a Cybex Norm dynamometer. The protocol consisted of 3 sets (separated by 30 s intervals) of 12 maximal repetitions of knee flexion (H) and extension (Q) of the dominant leg at 60°/s. Data analysis focused in particular on the total work parameter. Metabolic (ventilation, oxygen consumption, blood lactate concentration) and cardiovascular (heart rate, mean arterial blood pressure) parameters were recorded before, throughout and after the exercise session.

The total work developed during the exercise was significantly higher for the ECC compared to the CON mode. A third series / first series CON work ratio showed values of 0.72 and 0.77 respectively for the Q and H groups. The ECC fatigue ratio remained higher than 0.85, yet both muscle groups behaved differently: the ratio reached 0.95 in Q (nonsignificant decrease between third and first series) versus 0.86 in H (significant decrease between third and first series, \( p < 0.001 \)). The specific fatigue pattern observed in the flexors could be hypothesized as representing a risk factor of hamstring injury. Main findings related to the physiological response consisted of (1) significantly higher heart rate after the first set of repetition in CON (176 ± 20 versus 158 ± 9 bouts in ECC), (2) two minutes after the isokinetic intervention, oxygen consumption and blood lactate concentration were significantly higher in CON. Metabolic and cardiovascular variables (ventilation, oxygen consumption, lactate and heart rate) normalized by the isokinetic total work appeared higher in CON.

This study highlighted higher metabolic and cardiovascular solicitations during CON exercise compared to the ECC response. This finding should be taken into consideration when designing a strenuous isokinetic protocol.

References

Isokinetic and iso-inertial assessments: Competition or complementarity?

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The assessment of muscular performance is particularly important in exercise science and rehabilitation. Several testing methods are used in order to provide information about 1) effects of training and rehabilitation interventions 2) strength and velocity development linked to various athletics events and tasks 3) athletics profiles, and 4) muscle imbalance and risk factor for injuries [2,16,17]. Principal testing methods include isometric, iso-inertial, and isokinetic modalities. The chosen modality must have relevance to the performance of interest.

Isometric conditions remain useful in some very specific cases requiring static position (i.e. invasive EMG, RMN). However, the major limitation of isometric tests rests with the lack of specificity regarding human movements that regularly require dynamic activation of musculature [2,4,13,17]. For instance, determination of 1RM and vertical jumps have been widely used as a measure of dynamic muscular performance. The 1RM score is representative of the maximal strength for a given exercise but does not provide any information about muscular contraction velocity capacity [2,4,17]. By contrast vertical jumps concern lower limb explosive ability without giving any information about actual strength development.

Alternatively, isokinetic and iso-inertial dynamometers are both adapted to appraise muscle qualities in force, power and velocity under different loading conditions. Isokinetic assessment involves, for a given exercise, the measurement of torque, work and power through different constant angular velocities, allowing the description of torque-velocity and torque-power relationships [5,8,10]. Iso-inertial dynamometers measure the velocity and power exerted at different constant loads through common weightlifting exercises. This approach allows the description of load-velocity and load-power relationships [3,12,15]. As both dynamic methods present similarities, a clarification of their respective advantages and limitations and the context of their operation is very appropriate.

Isokinetic dynamometry has become a favoured method for the assessment of dynamic muscle function in both clinical research and sport environment [8,10,17]. The constant velocity allows a maximal activation of the muscle throughout almost the entire range of motion. Isokinetic tests mostly involve isolated muscular actions in an open kinetic chain (OKC) even if some devices offer a closed-kinetic chain (CKC) option. Single joint assessment allows exploration of a given specific muscle group with the exclusion of any other group. Such analytic approach aims at testing of both limbs and comparing values for asymmetry detection. Isokinetic testing simultaneously assesses agonist and antagonist muscle groups. An imbalance between reciprocal muscles has been associated with highest risks in muscle injuries, in particular for hamstring muscle groups [6]. Since isokinetic dynamometry offers a potentially safe and controlled environment for the quantitative examination of functional muscle capacity, it presents multiple applications in the clinical evaluation of muscular dysfunction and insufficiency following pathology, injury or surgical intervention [8,10,17]. Assessing eccentric actions with relative safe condition represents an original contribution to muscle function investigation. Eccentric contraction assessment is important because of its involvement in the stretch-shortening cycle (SSC) and in braking actions, frequently encountered during usual day life activities and sport movement. A preventive approach of muscle strain has been validated through preseason isokinetic testing in professional soccer player [7]. However in controlling the movement velocity and performing isolated single joint movements which are not totally representative of sporting actions, these devices are seen to lack application to competitive sports [2,17]. Isokinetic tests have not always provided data that accurately differentiate performance between athletes of varying skill levels. Several research demonstrated that isokinetic assessment bear little relationship to most sporting pursuits [2,4,16]. Nevertheless a few studies have highlighted relationships between isokinetic parameters and field performances [9,11]. It should be noted that isokinetic test results become less reproducible as the velocity of movement increases [8]. Over 300°/s and 120°/s respectively in concentric and eccentric the validity of isokinetic knee test appears insufficient [5]. This velocity limitation may become problematic, particularly in explosive movements encountered in some specific sports activities.

By contrast, the iso-inertial method allows examination of muscle output at all range of velocities (1–95% Vmax) throughout the movement range. With an iso-inertial dynamometer it is possible to analyse muscle limits in strength and in velocity while with isokinetic test only strength limits is allowed to be measured. The advantages of typical
iso-inertial testing are that the necessary equipment is often readily available and, at least for free weights, is relatively inexpensive [4]. Iso-inertial tests are mostly involving multi-joint movement like squat, bench press or leg press, however they can be performed using any muscle machine which uses gravitational forces as the external resistance [3,12]. Tests can be performed only concentrically or with stretch-shortening cycle (SSC) which represents the most natural pattern of muscle work. Because of its simplicity in use and application this method seems suitable for use in both the laboratory and the field [3,4,12–14,17]. Several researches demonstrated significant relationship between iso-inertial test and sport performances and confirmed the ability of iso-inertial assessment to detect specific training effects [1,13,15]. The fact that iso-inertial testing movements simulate some training components confers significant specificity and sensitivity. Iso-inertial dynamometry appears as a particularly relevant method to follow up resistance training in high level athletes. However, iso-inertial method presents some disadvantages. In order to avoid any learning effect the subject has to be well familiarised with the test [3,12]. It is important that the lifts are performed in a technically correct fashion, particularly for exercises that involve the lower back, such as squats, power cleans or deadlifts [12,17]. In order to get a reliable measure, the load displacement has to follow a linear trajectory. Furthermore during iso-inertial tests the amount of resistance stays limited to the weakest point in range of motion. In addition when the exercise is bilateral it is impossible to detect a muscular asymmetry. Agonist/antagonist strength ratio may not be established. The eccentric contraction study seems difficult to be performed and presents increased risk of injury, in comparison with the isokinetic concept.

In our opinion iso-inertial and isokinetic findings do not provide redundant information and therefore represent rather two complementary modern methods of muscle performance measurement. Isokinetics test are principally recommended for clinical applications (detection of muscle dysfunction, bilateral and reciprocal muscle imbalance) while iso-inertial assessment is recommended for resistance training follow-up and athletes profile identification.

References

Neural adaptation in the repeated bout effect of delayed onset muscle soreness

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Introduction: Many studies have demonstrated that a single bout of unfamiliar eccentric exercise induced delayed onset muscle soreness (DOMS) due to muscle damage [4]. It is established that a repeated bout of identical eccentric exercise results in reducing the symptoms. This adaptation has been mentioned as the repeated bout effect (RBE) which occurs bouts of eccentric activity involves the same limb [1]. Central and local mechanisms have been suggested, in the light of which we have hypothesised that a cross-over effect could take place. The aim of this study was hence to explore the RBE when the second bout of exercise was executed with the ipsilateral leg vs controlateral leg.

Materials and methods: Two groups of 11 moderately active male volunteers underwent an isokinetic eccentric provocation session consisting of 2 trials of 4 maximal contractions (at 60 °/s) of the hamstrings. After two weeks the same protocol was applied for the ipsilateral leg (group 1) and the controlateral leg (group 2). Before and after (at 24, 48, 72 hours) each session the following parameters were measured:

- Serum level of the creatine kinase (CK)
- Subjective intensity of pain using a visual analog scale (VAS)

These two parameters are commonly used as indirect indices of exercise-induced muscle damage. Statistical analysis was performed using Wilcoxon test for paired samples and Anova for repeated measures.

Results and discussion: In group 1 a significant reduction of 10 and 6% was observed for the PT and total work, respectively, during the second session. Despite this small decrease in intensity the session was considered adequate to provoke DOMS. For group 2 the statistical analysis did not show differences between eccentric sessions regarding peak torque and total work.

After the first session we observed a significant increase of CK serum level (at 48 h post-training) and pain for both group. These signs clearly identified the presence of DOMS.

The comparison of DOMS intensity after the second session showed a complete disappearance of DOMS for group 1 as no significant increase of CK serum level and pain were observed. In group 2 a significant decrease in the average maximal CK serum level (24200UI/l versus 12800 UI/l) and pain (p < 0.05) was demonstrated.

Conclusion: In contrast with Conolly [2], this study clearly demonstrates the existence of a crossover effect when analysing the RBE. This cross-over effect offers a protective effect of about 50% efficiency compared to that observed when the second bout of exercise is executed by the same muscular group. Recent advances in the understanding of the repeated bout effect suggest different theories. Potential adaptations have been categorized as neural, mechanical and cellular. The present results have shown that the adaptations are not only due to local phenomena. Thus, neural or systemic adaptation mechanisms could be considered.

References
Shoulder

Relationship between muscular performances of the shoulder and morphostatic profile

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Muscular force production and balance have been postulated to be major factors in postural alignment of a healthy population. Diveta et al. [1] have proposed that muscle weakness would affect postural alignment and that an imbalance in muscle strength could lead to postural deviations.

The aim of this study was to investigate the actual relationship between isokinetic strength of the shoulder and the morphostatic profile. 10 healthy sedentary men and 10 overhead athletes were involved into that study. They were tested bilaterally for internal (IR) and external (ER) rotation as well as for protraction (PRO) and retraction (RET) strength using a Biodex 3 dynamometer. For rotators isokinetic evaluation subjects were installed in supine position with the shoulder 90° abducted in the frontal plane. The protocol included two concentric velocities (3 repetitions at 60°/s and 5 repetitions at 240°/s). For the scapular (PRO/RET) strength subjects were installed in seating using the closed kinetic chain attachment, placed in the horizontal plane at 30° from the frontal plane (reproducing the scapular plane). Testing modalities corresponded to 3 repetitions at 12.2 cm/s and 5 repetitions at 36.6 cm/s.

According to a recent publication [2] all the shoulders were also tested goniometrically and morphostatically as follows:

- a goniometric assessment of the internal and external rotation, shoulder 90° abducted in the frontal plane and measurement of the horizontal adduction;
- a centimetric evaluation of the scapula position on the thoracic whole (the distances between spine of the scapula or inferior angle of the scapula and the corresponding closest spinous process);
- a measurement of the pectoralis minor tightness, subject in lying supine position, arms at rest on the side.

Strength, PT and peak force (PF) and the ratio (ER/IR, PRO/RET) profiles were established in both populations. The shoulder morphostatic features were determined as above mentioned. Thereafter possible correlations between muscle performances and postural or goniometric measurements were explored.

Considering the isokinetic results there were no significant differences between sedentary subjects and overhead athletes in absolute or in bodyweight normalized PT or PF. The ER/IR (0.75 at 60°/s for both populations) and PRO/RET (0.81 ± 0.17 for the sedentaries and 0.96 ± 0.17 for the athletes at 60°/s) showed no significant between-group difference. Good correlations (0.51 ≤ r ≤ 0.84) existed between the rotators and scapulothoracic muscles isokinetic assessments, mainly within the overhead athlete group.

The morphostatic measurements showed a specific profile in the overhead athletes population:

- a decrease in glenohumeral internal rotation (measured at 90° of abduction in the frontal plane) on the dominant shoulder;
- a larger upward rotation of the dominant (D) shoulder;
- a bilateral tightness of the pectoralis minor.

Only few correlations were found between morphostatic or goniometric measurements and isokinetic results. For the overhead athletes, a high ER/IR ratio at 60°/s (D side) corresponded to an adducted scapula (r = 0.73), and a high PRO/RET ratio at both velocities (D side) were related to a larger RoM in internal rotation (r > 0.67).

In conclusion, in spite of a trend to higher PRO/RET ratios within the overhead athletes we did not find an actual influence of sports activity on the isokinetic results concerning the ER-IR and PRO-RET muscle groups. Some goniometric and morphostatic specific features appeared in the athletic population yet only few correlations were found between isokinetic data and morphostatic measurements. For the overhead athletes, muscle balance seemed to influence the glenohumeral rotation or the scapular position at rest.
Isokinetic assessment of the scapular muscles

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The scapula plays an important role in normal shoulder function. In sports in which demands on the shoulder are extremely high, the quality of movements depends on the interaction between scapular and glenohumeral kinematics. Compared to a normal status scapular dyskinesis is defined as observable alteration in the position of the scapula and in the patterns of scapular motion in relation to the thoracic cage [3]. Surprisingly, only sparse literature focused on the isokinetic assessment of scapulothoracic muscles. To the best of our knowledge Cools et al. [1,2] are the only papers to have looked into this issue using a closed kinetic chain model.

The aim of this study was to provide new insights into the isokinetic assessment of scapular muscle performance among sedentary and overhead athletes populations. Ten sedentary men (23.5 ± 2.6 years; 67.3 ± 62 kg) and 10 overhead athletes (22.2 ± 2.3 years; 72.9 ± 9.7 kg) participated in the study. All subjects were free of previous shoulder pathology. The overhead population included 2 volleyball, 2 handball, 3 tennis and 3 badminton players, all with at least 9 years of intensive practice. Bilateral isokinetic assessment (Biodex 3 dynamometer) of the protractors (PRO) and retractors (RET) of the scapula (closed kinetic chain) was performed. Subjects were seated and the closed kinetic chain attachment was placed in a horizontal plane, at 30° from the frontal plane, which corresponded to the scapular plane; the elbow was placed in full extension. The RoM was individually adjusted from maximal protraction to maximal retraction positions.

After a specific warm up using Theraband and familiarization on the isokinetic dynamometer the protocol consisted of 3 repetitions at slow speed (12.2 cm/s) and 5 repetitions at high speed (36.6 cm/s). The strength performances (peak-force in N) and ratios (Protractors / Retractors; PRO/RET) are described in Tables 1 and 2.

Table 1

<table>
<thead>
<tr>
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<th>PRO 12.2 cm/s</th>
<th>PRO 36.6 cm/s</th>
<th>RET 12.2 cm/s</th>
<th>RET 36.6 cm/s</th>
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<td></td>
<td>(N/kg) means ± SD</td>
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<tr>
<td>Sedentaries</td>
<td></td>
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<tr>
<td>D</td>
<td>3.57 ± 1.19</td>
<td>3.40 ± 1.22</td>
<td>2.42 ± 0.94</td>
<td>2.41 ± 1.01</td>
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<tr>
<td>ND</td>
<td>3.66 ± 2.59</td>
<td>3.54 ± 2.26</td>
<td>2.59 ± 0.71</td>
<td>2.26 ± 0.71</td>
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<tr>
<td>Athletes</td>
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<tr>
<td>D</td>
<td>3.94 ± 1.34</td>
<td>3.82 ± 1.07</td>
<td>3.05 ± 0.98</td>
<td>2.71 ± 0.78</td>
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The maximum force developed by scapular muscles decreased with increase in motion velocity. Generally, there was no dominance effect, except for the RET at high speed within the sedentary population (Table 1). The PRO/RET ratios remained inferior to 1 indicating higher performances on RET muscle group (Table 2). Even if the athletes recruited in our study used their shoulder in an asymmetrical way we did not find any significant difference between the dominant and non dominant ratios in that population; only the PRO/RET ratio of the sedentary subjects at high speed showed a dominance effect. The PRO/RET ratios were higher in the athletes yet the difference did not reach statistical significance. There was no significant difference between groups considering the absolute strength or the bodyweight normalized peak force. The sports population appeared more homogenous with lower standard
deviation values for all data. Nevertheless in such closed kinetic chain assessment compensations of the trunk during protraction and of the elbow during retraction must be strictly controlled.

To sum up, shoulder testing in a closed kinetic chain configuration allows exploration of protraction and retraction strength. In spite of upper limb asymmetrical use through overhead activities, a dominance effect in strength performances or agonist-antagonist ratios was not detected among athletes recruited in that study. These preliminary results could be useful for further comparison with pathological cases.

References


Spine

Trunk isokinetics and amputation of the lower limbs

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The prevalence of low back pain is much higher in the amputee than in the general population: 71% [9].

The amputation generates several constraints by various biomechanical factors

– lower limb inequality of length [5], stiffness
– exaggeration of the amplitudes of movement during the walking, dynamic hyperlordosis [6]
– asymmetry of steps [8], asymmetry of girdle rotation [10].

These constraints increase when the level of amputation is high and during sporting practice [1,11].

Isokinetic tests of the lower limbs were carried out in amputees

At hip level the deficit was more marked in extension than in abduction [2]. At knee level, the deficit was more marked in extension than in flexion [3,4,7]. Moreover, the shorter the stump, the worse was the deficit. These deficits of hip extensors and hamstrings weaken the chain of extension of the trunk.
Trunk isokinetic tests

Subjects: 25 amputees, 13 femoral, 12 tibial; mean age: 27.9 years;
Aetiology: 18 traumatic, 1 burn injury, 1 congenital, 5 sarcoma
Prosthesis: CATCAM, silicone liner, dynamic feet and knees.
Design: Retrospective study of tests carried out between 1995 and 2000
Protocol: Concentric tests of extensors and flexors of the trunk were carried out with the prosthesis using the TEF (Cybex®) platform at 30 and 120°/s with a Rom of 75°.

Results

Compared to normative data we noted deficits of the extensors and flexors but no deviation in terms of the ratios. Trunk extensors power was lower in femoral compared to tibial amputees. The curves of extension often had a ‘lying S’ shape. This drop in muscular recruitment at the end of the extension may be related to the hyperlordosis which was compatible with infra-pelvic muscle stiffness or insufficiency of the pelvic extensors.

Conclusion

In our sample of 25 amputees trunk extensors and flexors were weak. Biomechanical factors as well as physical deconditioning could explain this marked deficit. Compared to femoral amputees tibial amputees had higher extension power. Lower limb amputees have potential factors of low back pain in the form of muscular deficit of the lower limbs and of the trunk, asymmetries and exaggeration of the movements. Preventive intervention aimed at trunk muscles reinforcement appears useful especially in case of femoral amputees.

References

Lower Body

Unexpected effects of dental occlusion on lower limb muscle strength development

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Factors contributing to strength alteration have received great attention from researchers and trainers since many decades. Studies have not only focused on mechanisms involved in improvement but also on factors leading to impairment. New advances in knowledge and research in this field would require more frequent interdisciplinary approach.

One original factor which has been recently advocated originates from the dental medicine focusing on temporomandibular joint (TMJ) dysfunction. However research was predominantly based on subjective criteria collected through simple questionnaires. The purpose of our double blind study was to objectively clarify the possible relationship between dental occlusion and muscle strength performances of the lower limbs. Twelve healthy female subjects totally free from TMJ disorders (mean age 23 years, extremes 21–33 years) were recruited. Each subject sustained a buccal exam including questionnaire, muscular and articular palpation, Farrar’s diagram and axiography. They were also free of any lower limbs past history of injury.

All subjects performed an isokinetic assessment (Cybex Norm dynamometer) of the quadriceps and flexor muscle groups. Peak torques were measured through concentric (60 and 240°/s) and eccentric (30°/s) actions. Assessments were conducted in three different jaw positions: (1) in maximum intercuspidation without splint (2) mouth closed on a balanced occlusal splint (to obtain simultaneous and distributed contact over the dental arch) and (3) mouth closed on a piece of resin of 1 mm applied on tooth 46 (to increase artificially the vertical dimension of occlusion). Tests were performed on the same day and the order was randomly assigned (30 min between each test). One experimenter ensured that the mouth remained closed during isokinetic testing.

Concentric performances did not show any significant difference between the 3 jaw positions, irrespective of the muscle group involved. By contrast significant differences ($p<0.05$) were observed in the eccentric tests relating to quadriceps strength during the resin condition and the two other modalities (without splint or with a balanced splint). For these modalities the imbalanced occlusion created by the resin component entailed an average decrease of 9\% in peak torque. The eccentric flexion peak torques also showed a significant difference ($p<0.05$) between measurements with splint and with resin (7% decrease when occlusion was imbalanced).

These results indicate that an occlusal interference created artificially among subjects without occlusal and TMJ disorders immediately induces muscle strength alteration. The peak lower limb torque reduction specifically concerns the eccentric mode of contraction. Further studies would clarify the possible implications in sports training and the underlying neurophysiological mechanisms.

Analysis of a fatigue protocol for knee extensor and flexor muscle groups

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Complementary to muscle strength measurement, isokinetic dynamometry offers the opportunity to investigate another essential variable: the fatigue which can be defined as a deterioration in maximum torque generating capacity. Many articles refer to isokinetic fatigue protocols yet there is a lack of consensus about testing modalities and
methodological aspects. The overall aim of this preliminary study was to investigate concentric fatigue protocols in terms of contraction number, measurement reproducibility and compatibility of relevant parameters.

Twelve male subjects (23 ± 2 years old; 71 ± 3 kg) without history of lower limb injury took part in the study. After standardized warm-up and familiarization with the isokinetic exercise (Biodex 3 dynamometer) each subject performed a unilateral concentric testing on his dominant side knee flexors and extensors. The protocol consisted of 50 maximal contractions at 180°/s along a constant 100° range of motion. The fatigue protocol was repeated at 3 different sessions, separated by one week, in the same standardized conditions.

Measured and calculated parameters were analysed: maximal work (Wmax); total work (Wtot); cumulative work on 10-20-30-40-50 repetitions (W10-20-30-40-50); different fatigue indexes: mean of the 3 last reps/Wmax (W3L/Wmax), mean of the 5 last reps/Wmax (W5L/Wmax), W3L/mean of the 3 first reps (W3L/W3F), W5L/mean of the 5 first reps (W5L/W5F). These fatigue indexes were established from the 50 repetitions protocol but were also calculated on the first 30 and 40 repetitions. The heart rate (HR) throughout the fatigue protocol was recorded using a Polar cardiofrequencemeter.

A generalized linear mixed model (GLMM) was used for the statistical analysis of reproducibility.

The cumulative work calculated on 20, 30, 40 or 50 repetitions was found to be reproducible for the extensors. The same parameters calculated with respect to the flexors showed a less satisfactory reproducibility. Among indices of fatigue the most reproducible were those using Wmax as denominator (by contrast with W3F or W5F as denominator), in particular the W5L/Wmax index for the extensors. From 20 repetitions to the end of exercise the fatigue indices calculated for the flexors were significantly (p < 0.05) inferior to the indices established for the Q suggesting a more marked effect of fatigue on the former in terms of maximal strength production. With respect to the HR expressed in percentage of the theoretical maximal HR, the value averaged 53% before exercise, 83% after 20 reps and peaked at 87% after 50 reps. After 2 minutes of recovery, the HR reached 58% of the HR max.

These findings must be taken into account when designing a fatigue isokinetic protocol, in terms of exercise duration and the parameters to be analysed.

Electromyographic activity of knee flexors and extensors during isokinetic fatigue assessment

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Objective: The objective of our study was to measure EMG patterns during an isokinetic fatigue protocol performed on the knee flexor and extensor muscles.

Methods: Twelve healthy males (23 ± 2 years old; 71 ± 3 kg) without history of lower limb injury were included in the study. After a warm-up and familiarization on the dynamometer (Biodex 3) all subjects performed a concentric isokinetic test on their dominant side knee flexors and extensors. The assessment was conducted along a constant range of motion from 0° to 100° of flexion. Subjects performed, in the same conditions, three sessions (separated by 1 week) of 50 maximal knee extensions and flexions. A general linear mixed model was established in order to compare EMG patterns between the 3 test sessions. Six sequences consisting in 3 consecutive flexion-extension movements (1\textsuperscript{st} to 3\textsuperscript{rd}, 8\textsuperscript{th} to 10\textsuperscript{th}, 18\textsuperscript{th} to 20\textsuperscript{th}, 28\textsuperscript{th} to 30\textsuperscript{th}, 38\textsuperscript{th} to 40\textsuperscript{th} and 48\textsuperscript{th} to 50\textsuperscript{th} repetitions) were compared to determine EMG pattern during the isokinetic exercise. Electrical activities (\textmu V) of the vastus medialis (VM), rectus femoris (RF), internal hamstrings (IH) and external hamstrings (EH) were recorded from surface electrode using a standard surface EMG procedure (Noraxon Myosystem). All electrical activities were rectified and smoothed (RMS 50). EMG signals were measured for agonist and antagonist electrical activities (e.g. recruitment of flexor muscles respectively during flexion and extension knee efforts).

Results: Reliability of agonist EMG activity measurements appeared satisfactory for each muscle in contrast with antagonist EMG activities. Significant time effect was observed for agonist EMG activities during the fatigue
EMG agonist activities

Fig. 1. Profile of VM, IH and EH agonist EMG activity (expressed in % of maximal RMS) during the isokinetic fatigue assessment.

EMG agonist activity

Fig. 2. Profile of RF agonist EMG activity (expressed in % of RMS maximal) during the isokinetic fatigue assessment.

protocol. Patterns of agonist EMG activities of VM, IH and EH appeared similar. We observed a rise of agonist electrical signal after 10 movements followed by a progressive reduction of electrical activities (Fig. 1). EMG pattern recorded on RF appeared to be different (Fig. 2).

Discussion and conclusion: Reliability of agonist EMG activities appeared satisfactory throughout 3 sessions of isokinetic fatigue assessment. We demonstrated a similar agonist EMG pattern of VI, IH and EH. In contrast, we observed an original profile of RF agonist EMG activity. This specific profile might result either from the polyarticular function of RF in a seated position or from a different muscle typology. Our preliminary findings challenge the relevance of data recorded during antagonist activity for each muscle group.
Influence of hip position on EMG activity and strength of knee muscles

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Abstracts

Influence of hip position on EMG activity and strength of knee muscles

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Background and Objective: Although several studies have demonstrated a direct linear relationship between muscle length and isometric force, controversy remains with respect to this issue as well as regarding EMG activity. The conflicting findings motivated the present study whose objective was to investigate the relationship between knee muscles length and EMG activity and isokinetic strength.

Materials and methods: Eighty healthy male students with no history of knee, hip or low back pathology participated in the study. The tests were performed using a Cybex Norm® and consisted in the first stage of 3 maximal isometric contraction of the quadriceps at an 60° flexion with 60 s rest followed by 3 maximal isometric contraction of the hamstring at an angle of 30° in order to obtain the Maximal Voluntary Contraction (MVC). Each isometric contraction lasted 5 s. During the tests EMG activity was recorded from the vastus lateralis (VL), vastus medialis (VM), rectus femoris (RF) and hamstring (H) using a Noraxon Myosystem 2000. The best motor unit recruitment use of each muscle were taken into account with a view to normalizing our sEMG data in percentage of MVC. The second stage of the protocol consisted of 3 isokinetic contractions at 60°/s measured in four different hip joint angle. The order of testing was systematic: 1) hip flexed to 90° (sitting upright); 2) hip flexed to 45° (leaning back); 3) 0° degree of hip flexion (supine) and hip flexed to 110° (leaning forward). The protocol was executed bilaterally. Subjects were given 90 seconds rest period between each position.

Results: No significant difference in quadriceps torque were revealed between 90°-45° hip flexion but a comparison between extreme positions indicated significant differences (p< 0.001). In contrast, H Peak torque was significantly influenced by hip position. The sEMG showed a relative constant activity during each position, except for VM between 90° and 0° and 110° and for RF between 110° and the remaining positions. In flexion, H Peak torque was also significantly influenced by the position, whereas no significant sEMG was observed.

Discussion: The results of this study indicate that knee muscles develop a greater amount of torque in the position of 90° hip flexion. This position probably places the muscles in a favorable portion of their length-tension curve. On the other hand, most subjects experienced discomfort in the 110 deg hip position as the knee extension caused many difficulties.

There seems to be a length at which the ratio between muscle force and EMG activity is the greatest and the most efficient. Much controversy over the effect of hip position on knee extension force is found in the literature [1,3]. Some authors [5] consider quadriceps as a single joint muscle because of the small contribution of the rectus femoris
as this is the only biarticular muscle. Nevertheless, we observed a stability of EMG for the hamstring which is a
typical biarticular muscle. The force developed by the active contractile elements is governed by the relative position
of the acting myosin filaments of each sarcomere.

In conclusion the stability of the EMG in spite of the shortened position is not in accord with previous studies [2,
4] which showed a decrease or an increase of myo-electrical activity in a shortened position. It also seems that a
seated upright position might be the “ideal” position to achieve the best torque and motor unit recruitment although
in certain clinical instances it might be beneficial to decrease torque or recruitment.

References

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Isokinetic evaluation of the ankle evertors and invertors in athletes: Relationship with the sport discipline
and medical history of lateral collateral ligament ankle sprain

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Background: Lateral ankle sprain is a frequent injury in sport [3]. Despite a codified initial treatment, there are
often incapacitating after effects: recurrent sprain, chronic pain and chronic ankle instability [2] which is sometime
attributed to evertor weakness [7]. Indeed, ankle stability depends on co-activation of the antagonists [1] and there
is a possible relationship between muscular imbalance and injuries [6].

Objective: To evaluate inversion and eversion muscle balance in the ankle in different sports athletes taking into
consideration side dominance and previous medical history of ankle sprain.

Methods: Forty athletes: 34 men and 6 women, 15 to 40 years old, cross-country runners, sprinters and jumpers
took part in the study. Twenty eight had a previous history of lateral collateral ligament ankle sprain, 14 in the
dominant side, 12 in the non-dominant and 2 bilateral cases. None had an acute lower limb pathology. Ankle
inversion and eversion concentric muscle strength was measured at 30°/s and 120°/s whereas ankle eversion strength
was also assessed eccentrically at 30°/s using a CON-TREX® isokinetic dynamometer.

Results: In jumpers, evertor strength was lower on the non-dominant side. There was no difference between
runners and sprinters (Fig. 1). Among athletes with unilateral ankle sprain there was no difference between muscle
strength of the non-involved ankle and the strength of the corresponding muscles among the controls. However there
was a weakness of the evertors of the involved ankle in previously injured athletes but only at the non-dominant
foot (Fig. 2). Moreover there was a relationship between weakness of the evertors and functional sign of discomfort
(Fig. 3).

Discussion and conclusions: Although the existence of evertor weakness in ankle sprain [7,8] is debatable [4,5]
the present study revealed such weakness in athletes with previous history of ankle sprain coupled with functional
signs of discomfort. Some differences in the invertors and evertors balance of the ankle are related to the sport
discipline and to a medical history of lateral collateral ligament ankle sprain.
Eversors ankle strength at 30 /s and athletic discipline

Fig. 1.

Evertors ankle peak torque at 120 /s and medical history of ankle sprain

Fig. 2.

References


Eversors ankle strength at 30 /s and functional sign of discomfort

![Graph showing peak torque (N) for involved and non-involved ankles with functional sign and without functional sign.]

**p<0.02

Fig. 3.


Miscellaneous

Isokinetic strength and fatigability in patients with multiple sclerosis: The relationship between gait speed and isokinetic parameters

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Introduction: Multiple sclerosis (MS) is a chronic disease characterized by inflammation and demyelisation of the central nervous system. Decline of muscular performances, fatigue, weakness and spasticity are the most common and disabling symptoms characterizing this neurological disease.

Undoubtedly, objective assessments of muscle function would be relevant to deliver the most appropriate treatment and to appraise possible training effects resulting from rehabilitation.

The objectives of this study were to assess muscle strength and fatigue of knee flexors and extensors in patients with multiple sclerosis by means of an isokinetic dynamometer. Relations between isokinetic results and gait speed were also investigated.

Methods: Eight patients (49 ± 7 years old) suffering from multiple sclerosis (with unaided gait) were included in this study. Bilateral knee flexor and extensor performances were assessed using a Cybex Norm dynamometer.
Maximal isokinetic strength was measured at 60°/s (3 repetitions) and 180°/s (5 repetitions). Thereafter, patients performed a fatigue protocol consisting of 30 successive maximal-intensity knee flexions and extensions at 180°/s. Fatigue was analysed using the cumulative work parameter (corresponding to the sum of work developed through the 30 movements) and a fatigue index (ratio between work developed during 3 last contractions and 3 first contractions). Gait speeds corresponded to the time necessary for a patient to walk at maximal speed on a 7.62 m and 100 m long walkway.

Results: Isokinetic parameters (strength and fatigue) appeared to decrease in MS patients compared to normal subjects [1]. Knee flexors/extensors ratio was reduced for some patients, yet MS subjects displayed no significant bilateral asymmetry, suggesting a bilateral weakness process.

Significant negative correlations (−0.76 < r < −0.95, p < 0.05) between gait speeds and hamstring isokinetic parameters (peak torque and cumulative work) were observed. In contrast, we did not find any correlation between gait speed and quadriceps isokinetic performances, except for the correlation between gait speed on 100 m long walkway and fatigue index (0.78 < r < 0.89, p < 0.05).

Discussion and conclusion: Objective evaluation of muscle performance deficiencies in patients with MS appears essential for designing a successful rehabilitation program. However, no consensus has been established with regard to the most relevant isokinetic protocol modalities for assessing patients suffering from central nervous system lesions. Our preliminary results underlined that gait speed was negatively correlated to hamstring isokinetic parameters (strength and cumulative work). Interestingly, no patient included in our study reported increased symptoms such as spasticity during or after the test, indicating that MS patients are able to perform strength and fatigue isokinetic assessments.

Reference


Whole body vibration in the treatment of fibromyalgia: Influence on muscle performances

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Introduction: Whole-body vibration (WBV) is a neuromuscular training method that has rapidly gained popularity in health and fitness centres. However limited data are available about the benefits of WBV on muscular performances. The aim of this study was to investigate implementation of this treatment in fibromyalgia patients. Specifically we have assessed patient tolerance to WBV sessions and its consequences with respect to muscle performance in these patients.

Material and methods: Twenty-three women suffering from fibromyalgia participated in the study. Patients were split into 2 groups: WBV (n = 13, 46 ± 4 years old, 71 ± 5 kg) and control (n = 10, 47 ± 3 years old, 65 ± 4 kg). During a 10-week experimental period, all subjects were involved in an aerobic rehabilitation program. Patients allocated to the WBV group also performed static exercises on a vibration platform (30–35 Hz, 1.5–3 mm, Gymna Fitvibe Medical®) twice a week. Outcome measures were recorded by means of the chair rising test, isokinetic measurements (strength and fatigue protocols), a static endurance test, an ergometer test and the sit and reach test. Pain was evaluated by means of a Visual Analogue Scale (VAS) and a dolorimeter. Other endpoints were the Fibromyalgia Impact Questionnaire score (FIQ), the Fatigue Severity Scale score (FSS), the Hospital Anxiety and Depression score, the Health Status score and the Satisfaction score.

Results: Benefits of aerobic rehabilitation in fibromyalgia patients have been documented previously [1]. In our study, muscle performance improved in both groups of patients at the end of the training programs. The chair rising test and the fatigue isokinetic assessment (with regard to relative cumulative work of knee flexors) indicated greater
training-induced changes in the WBV group than in the control group (respectively \( p = 0.0001 \) and \( p = 0.02 \)). No significant difference between groups occurred with regard to pain, FIQ and FSS scores. Ten patients (77%) of the WBV group completed the program and the results of the satisfaction questionnaire indicated that the patients were favourable to benefit from additional WBV sessions.

**Conclusion:** This study confirms that fibromyalgia patients can perform WBV exercises in safe conditions. The benefits of the additional WBV exercises on muscle function remain to be further explored.

**Reference**


**Enhancement of isokinetic muscle strength through a combined training program in chronic heart failure**

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**Background:** Patients with Chronic Heart Failure (CHF) exhibit an impaired exercise tolerance that critically limits their functional capacity and alters their quality of life.

**Design:** The aim of this study was to compare the effects of two types of training programs on isokinetic muscle strength and aerobic capacities in CHF patients.

**Methods:** A group of 23 stable CHF patients was included consecutively and followed an exercise training program, 3 days a week during 8 weeks. The first group (P1, \( n = 11 \)) exercised on a cycle ergometer for a period of 45 minutes at 65% of maximal peak \( V'\text{O}_2 \). The second group (P2, \( n = 12 \)) followed a 45 minutes combined quadriiceps strength and bicycle training and strength training consisting of 10 series of 10 repetitions at 70% of maximal voluntary force. Incremental maximal cardiopulmonary exercise tests as well as an isokinetic evaluation of the quadriiceps were performed before and after training.

**Results and conclusions:** In P1 peak \( V'\text{O}_2 \) increased by 20% (22.3 ± 4.9 vs. 17.8 ± 4.5 ml.min\(^{-1}\).Kg\(^{-1}\); \( P < 0.05 \)) without any significant change in isokinetic muscle strength. In P2, peak \( V'\text{O}_2 \) improved similarly (20.5 ± 2.8 vs. 18.6 ± 3.7 ml.min\(^{-1}\).Kg\(^{-1}\); \( P < 0.01 \)). This rehabilitation program significantly increased isokinetic strength at each angular velocities (+10.5 ± 13.5%; +5.6 ± 7.0; \( p < 0.03 \), 180°/s and 60°/s respectively). Only the combined endurance/strength training program was associated with an improvement in both peak \( V'\text{O}_2 \) and peripheral muscle strength, two significant parameters of outcome and quality of life in CHF.

**Keywords:** Combined training, isokinetic evaluation, CHF, cardiac rehabilitation.