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Isoinertial Training

Scientific Articles

Decresasing Injury Risks

Difference in the magnitude of muscle damage between elbow flexors and knee extensors eccentric exercises

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Abstract

The aim of this study was to investigate the difference in the magnitude of muscle damage between maximal eccentric exercises of the elbow flexors (EF) and knee extensors (KE). Twelve sedentary male volunteers participated in the study. Range of motion (ROM), isometric peak torque (IPT), delayed onset of muscle soreness (DOMS), creatine kinase activity (CK), and myoglobin concentration (Mb) were evaluated before, immediately after, and on the 1st , 2nd, 3rd , and 7th days following exercise. Total work (TW) during exercises was recorded and corrected by muscle volume (TWc). TWc was greater ($p < 0.01$) for EF [24 (2) joule·cm^{-3}] than for KE [7 (0.4) joule·cm^{-3}]. Increases in CK on the 2nd , 3rd , and 7th days ($p < 0.01$) and increases in Mb on the 1st , 2nd , 3rd , and 7th days were significantly ($p<0.01$) larger for EF than for KE. The decline in IPT was greater ($p < 0.05$- 0.01) for EF at all test occasions compared with KE. The results of this study demonstrate that the magnitude of muscle damage is greater and the recovery is slower following maximal eccentric exercise of the EF than of the KE for sedentary males.

Key words: Maximal eccentric exercise, muscle damage, creatine kinase, muscle volume.

LITERATURE REVIEW

A SYSTEMATIC REVIEW OF THE EFFECTIVENESS OF ECCENTRIC STRENGTH TRAINING IN THE PREVENTION OF HAMSTRING MUSCLE STRAINS IN OTHERWISE HEALTHY INDIVIDUALS

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ABSTRACT

Background. Hamstring strains are the most common soft-tissue injury observed in recreational and athletic activities, yet no consensus exists regarding appropriate primary and secondary strategies to prevent these strains. Eccentric exercise has been reported to reduce the incidence of hamstring strains but its role has not been clearly defined.

Objective. The objective of this systematic review was to determine the effectiveness of eccentric exercise in preventing hamstring strains.

Data Sources. Online databases, including MEDLINE, PubMed, CINAHL, PEDro, SPORTDiscus, EMBASE, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, and Web of Science were searched for relevant articles. Each database was searched from the earliest date to July 2007.

Study Selection. Selection criteria included diagnosis of hamstring strain, otherwise healthy individuals, and at least one group receiving an eccentric exercise intervention. Seven articles {three randomized controlled trials (RCTs) and four cohort studies} met the inclusion criteria.

Data Extraction. Data were extracted using a customized form. Methodological rigor of included studies was assessed using the PEDro scale and Oxford Centre for Evidence-based Medicine Levels of Evidence.

Data Synthesis. Studies were grouped by eccentric exercise intervention protocol: hamstring lowers, isokinetic strengthening, and other strengthening. A best-evidence synthesis of pooled data was qualitatively summarized.

Conclusions. Findings suggest that eccentric training is effective in primary and secondary prevention of hamstring strains. Study heterogeneity and poor methodological rigor limit the ability to provide clinical recommendations. Further RCTs are needed to support the use of eccentric training protocols in the prevention of hamstring strains.

Key Words: eccentric; hamstring strain; prevention

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Eccentric Work Effects

Flywheel resistance training calls for greater eccentric muscle activation than weight training

Lena Norrbrand · Marco Pozzo · Per A. Tesch

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Abstract Changes in muscle activation and performance were studied in healthy men in response to 5 weeks of resistance training with or without "eccentric overload". Subjects, assigned to either weight stack (grp WS; $n = 8$) or iso-inertial "eccentric overload" flywheel (grp FW; $n = 9$) knee extensor resistance training, completed 12 sessions of four sets of seven concentric–eccentric actions. Pre- and post-measurements comprised maximal voluntary contraction (MVC), rate of force development (RFD) and training mode-specific force. Root mean square electromyographic (EMG_{RMS}) activity of mm. vastus lateralis and medialis was assessed during MVC and used to normalize EMG_{RMS} for training mode-specific concentric (EMG_{CON}) and eccentric (EMG_{ECC}) actions at 90°, 120° and 150° knee joint angles. Grp FW showed greater ($p < 0.05$) overall normalized angle-specific EMG_{ECC} of vastii muscles compared with grp WS. Grp FW showed near maximal normalized EMG_{CON} both pre- and post-training. EMG_{CON} for Grp WS was near maximal only post-training. While RFD was unchanged following training ($p > 0.05$), MVC and training-specific strength increased ($p < 0.05$) in both groups. We believe the higher EMG_{ECC} activity noted with FW exercise compared to standard weight lifting could be attributed to its unique iso-inertial loading features. Hence, the resulting greater mechanical stress may explain the robust muscle hypertrophy reported earlier in response to flywheel resistance training.

Keywords Concentric and eccentric actions · Electromyography · Iso-inertia · Resistance exercise

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Introduction

Skeletal muscle inherently possesses greater mechanical efficiency and ability to generate force in lengthening [eccentric (ECC)] than shortening [concentric (CON)] actions (Katz 1939; Komi and Buskirk 1972). Thus, the electromyographic (EMG) amplitude is less while lowering (ECC) than lifting (CON) a given weight (Moritani et al. 1987). In fact, the CON EMG amplitude may be more than twofold higher, inferring markedly less motor unit involvement in ECC than CON actions (Nardone et al. 1989). Such a response is paralleled by much less exercise-induced contrast shift of magnetic resonance images of muscle, following ECC actions (Adams et al. 1992). Thus, the metabolic demand is less when lowering (ECC) than lifting (CON) a given weight (Asmussen 1953; Dudley et al. 1991). EMG amplitude may also be lower in ECC than CON actions executed with maximal effort (Aagaard et al. 2000). Collectively, it appears that more load is placed upon each active muscle fiber in the ECC action. This may at least in part explain the greater hypertrophy reported following chronic resistance training comprising coupled ECC and CON actions or ECC actions compared with CON actions only (Hather et al. 1991; Higbie et al. 1996; Hortobagyi et al. 1996).

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ORIGINAL ARTICLE

Resistance training using eccentric overload induces early adaptations in skeletal muscle size

Lena Norrbrand · James D. Fluckey · Marco Pozzo · Per A. Tesch

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Abstract Fifteen healthy men performed a 5-week training program comprising four sets of seven unilateral, coupled concentric–eccentric knee extensions 2–3 times weekly. While eight men were assigned to training using a weight stack (WS) machine, seven men trained using a flywheel (FW) device, which inherently provides variable resistance and allows for eccentric overload. The design of these apparatuses ensured similar knee extensor muscle use and range of motion. Before and after training, maximal isometric force (MVC) was measured in tasks non-specific to the training modes. Volume of all individual quadriceps muscles was determined by magnetic resonance imaging. Performance across the 12 exercise sessions was measured using the inherent features of the devices. Whereas MVC increased ($P < 0.05$) at all angles measured in FW, such a change was less consistent in WS. There was a marked increase ($P < 0.05$) in task-specific performance (i.e., load lifted) in WS. Average work showed a non-significant 8.7% increase in FW. Quadriceps muscle volume increased ($P < 0.025$) in both groups after training. Although the more than twofold greater hypertrophy evident in FW (6.2%) was not statistically greater than that shown in WS (3.0%), all four individual quadriceps muscles of FW

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REVIEW

The evolution of eccentric training as treatment for patellar tendinopathy (jumper's knee): a critical review of exercise programmes

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Background and aim: Eccentric training has become a popular treatment for patellar tendinopathy. Our purpose was to review the evolution of eccentric strength training programmes for patellar tendinopathy with a focus on the exercise prescriptions used, to help clinicians make appropriate choices and identify areas needing further research.
Methods: A computerised search of the entire MEDLINE database was performed on 1 September 2006 to identify prospective and randomised clinical trials with a focus on clinical outcome of eccentric training for patellar tendinopathy.
Results: 7 articles with a total of 162 patients and in which eccentric training was one of the interventions, all published after 2000, were included. The results were positive, but study quality was variable, with small numbers or short follow-up periods. The content of the different training programmes varied, but most were home-based programmes with twice daily training for 12 weeks. A number of potentially significant differences were identified in the eccentric programmes used: drop squats or slow eccentric movement, squatting on a decline board or level ground, exercising into tendon pain or short of pain, loading the eccentric phase only or both phases, and progressing with speed then loading or simply loading.
Conclusion: Most studies suggest that eccentric training may have a positive effect, but our ability to recommend a specific protocol is limited. The studies available indicate that the treatment programme should include a decline board and should be performed with some level of discomfort, and that athletes should be removed from sports activity. However, these aspects need further study.

Rehabilitation

ORIGINAL ARTICLE

Eccentric treatment for patellar tendinopathy: a prospective randomised short-term pilot study of two rehabilitation protocols

Anna Frohm, Tönu Saartok, Kjartan Halvorsen, Per Renström

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Objective: To compare the efficacy and safety of two eccentric rehabilitation protocols for patients with symptomatic patellar tendinopathy. A new eccentric overload training device was compared with the present standard eccentric rehabilitation programme on a decline board.

Design: Prospective, randomised clinical trial.

Setting: Sports rehabilitation clinic, university sports laboratory, supplemented with home exercises.

Patients: 20 competitive and recreational athletes, all with clinical diagnosis of patellar tendinopathy, verified by MRI or ultrasound imaging.

Interventions: A 12-week rehabilitation period, either with bilateral eccentric overload strength training using the Bromsman device twice a week or with unilateral eccentric body load training using a decline board twice a week, supplemented with daily home exercises.

Outcome measures: The primary outcome was pain and function, assessed by the Swedish Victorian Institute of Sport Assessment for Patella (VISA-P) score. Secondary outcome measures were isokinetic muscle torque, dynamic function and muscle flexibility, as well as pain level estimations using visual analogue scale (VAS). Side effects were registered.

Results: Both treatment groups improved in the short term according to the VISA-P scores during the 12-week rehabilitation period. However, there were no significant differences between the groups in terms of pain and function. After a 3-month rehabilitation period, most patients could be regarded as improved enough to be able to return to training and sports. No serious side effects were detected in either group.

Conclusion: In patients with patellar tendinopathy pain, two-legged eccentric overload training twice per week, using the new device (Bromsman), was as efficient and safe as the present standard daily eccentric one-legged rehabilitation-training regimen using a decline board.

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Desmotec Articles (1)

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ISOKINETIK

ECCENTRIC POWER AND RETURN TO SPORT AFTER ACL RECONSTRUCTION

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Introduction

This study tried to assess the eccentric strenght deficit during the last rehabilitation phase after ACL reconstruction and the recovery of such deficit after resuming agonistic sport activity. As a matter of fact, many studies have lately focused their attention on the recovery of the eccentric strength by means of rehabilitation protocols with early high intensity resistance exercises stimulating the eccentric phase(1) (3).

Conclusions : On the basis of such data, although the number of individuals examined was relatively small, we can infer that a high percentage of amateurish athletes probably resume their agonistic sport activity with a significant eccentric strength deficit which will be recovered gradually during (and by means) of the agonistic activity.

During such phase, the risk of getting injured again is obviously higher. Rehabilitation protocols should include eccentric training (also using a flywheel isoinertial device) even during the first post surgical phase as many studies have shown that such training is safe (2). We suppose that the eccentric training may help the recovery of the eccentric/concentric ratio before restarting a full agonistic activity.

	Uninvolved limb			Involved limb		
	Eccentric	Concentric	Ratio Ecc/conc	Eccentric	Concentric	Ratio Ecc/conc
4-8 months after ACLR	343±285	330±288	1.08±0.18	286±252	319±294	0.92±0.11
12-24 months after ACLR	395±167	366±159	1.09±0.11	435±203	412±246	1.13 ±0.23

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Desmotec Articles (2)

ISOINERTIALEXERCISE DOES NOT CAUSE CLINICALLY SIGNIFICANT MUSCLE DAMAGE: A PILOT STUDY

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INTRODUCTION

Eccentric exercise has often been associated with skeletal muscles structural damage and athletes may experience signs and symptoms such as limited range of motion and muscle soreness of the muscles across the joint. The isoinertial modality provides additional eccentric load (1). To our knowledge, no previous study has investigated the effect of isoinertial exercise, which consists of both concentric and eccentric muscular actions, on exercise-induced muscle damage. Aim of the present study is to measure changes in exercise-induced muscle damage and soreness as result of one isoinertial concentric-eccentric maximal exercise session.

METHODS

Six healthy amateur football and gaelic football players (3 males, 3 females, age 21.7±0.7 years, mean±SD; height 173.6±8.6 cm;weight 70.3±11.2 kg;training volume 3.5±1.7 sessions/week) volunteered in this study. DOMS was assessed using a Graphic Pain Rating Scale, GRPS, (2). Serum Creatine Kinase (CK) was measured from blood samples using kits for Randox Daytona Analyzer (Randox Laboratories Ltd., Co. Antrim, UK). CK and Delayed Onset Muscle Soreness, (DOMS) were assessed at baseline, 24 hours, 48 hours and 72 hours after a training session consisting of 4 sets of 7 maximal repetitions of a standing-semisquat exercise using a flywheel equiment (Desmotec, Italy), starting with the knees flexed. The inertial mass of the flywheel was 1.8 kg and its radius 0.143 m.A similar training session performed 2/3 times a week for 5 weeks has improved strength and increased muscles's size (3).

RESULTS

Baseline CK levels ranged from 71 to 303 IU/l (n=6, 136±95.6 IU/l). Peak CK, i.e. the highest values measured in samples collected 24, 48 and 72hours after the training session, was 204.0±88.0 IU/l, significantly higher than baseline CK (p=0.029). Values as Mean ± Standard Deviation. All the participants did not experience DOMS ("no pain" in the GPRS scale) after the training session.

DISCUSSION

Isoinertial training does not cause a clinically significant muscle damage and athletes undergoing such a training do not experience DOMS. In conclusion, isoinertial training using a flywheel device is safe and it stimulates muscles in a way similar to other forms of training.

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Desmotec Articles (3)

CARDIOPULMONARY RESPONSE DURING ONE SESSION OF MAXIMAL ISOINERTIAL TRAINING

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INTRODUCTION

The use of the flywheel resistance training has been shown to provide an increased eccentric muscle loading (1) and improve strength (2). Little research has been carried out on the effects the flywheel strength training session has on the cardiopulmonary system (3).The aim is to assess cardiopulmonary responses in amateur footballers undertaking isoinertial training.

METHODS

8 healthy male amateur footballers (age 19.5±2.3 years, weight 73.6±5.2 kg, height 180.4±5.2 cm) participated in this study. The inertial mass of the flywheel was 1.8 kg and its radius 0.143 m (Desmotec, Italy). The subjects performed 4 sets of 7 maximal repetitions, as per protocols shown to be effective to improving strength (2). After a familiarisation session, they were told to bend their knees down to 90 degrees flexion, stop the flywheel and extend at maximum speed, starting from a semi squat position. They were allowed to rest for 30 seconds between sets. Cardiopulmonary parameters were measured continuously throughout the test, oxygen uptake (VO_2) and carbon dioxide (CO_2) measured breath by breath by a portable gas analyser (Cosmed K4, Italy). The HR was measured by a heart rate monitor (Polar, Finland) throughout the test and blood lactate samples was taken from the earlobe at the end of the session and 3 and 5 minutes post completion of the four sets of exercise (LT-1710, Arkray, Japan). The highest value of lactate concentration was included in the present report.

RESULTS

The average (± standard deviation) values recorded in our athletes during an isoinertial training session were as follows: Heart rate was 126.5 ± 18.4 beats per minute, VO_2 ($mlO_2/min/kg$) was 22.65 ± 2.60, respiratory quotient was 0.92 ± 0.08, blood lactate concentration was 2.53 ± 1.36

DISCUSSION

According to our preliminary data an isoinertial intermittent training session elicits cardiopulmonary responses within the aerobic range of metabolic intensities. Further research will focus on cardiopulmonary responses to different isoinertial masses and protocols.

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Desmotec Articles (4)

ENHANCED POWER AFTER A 4-WEEK SUBMAXIMAL ISOINERTIAL TRAINING: A PILOT STUDY

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INTRODUCTION

The use of intermittent isoinertial maximal training has been shown to provide a form of eccentric overload exercise (1) and to improve strength (2) with minimal volume (4 sets of 7 maximal reps, 2-3 times a week for 5 weeks). Little research has been carried out on the effects of isoinertial training at submaximal intensity.

METHODS

Nine healthy male (n=8) and female (n=1) participants (age 35.4±8.4 years, weight 71.9±7.9 kg, height 173.9±6.4 cm, BMI 23.7±1.7 kg/m^2) volunteered and signed an informed consent to take part to the study, which was carried out according to the Declaration of Helsinki. The inertial mass of the flywheel was 1.8 kg and its radius 0.143 m (D11, Desmotec, Italy). The exercise was a semisquat movement performed so that concentric and eccentric phases were coupled in a closed kinetic exercise. As participants were "harnessed" just above the hip joint, the muscles moving the ankle, knee and hip joints were loaded concentrically and eccentrically at each repetition. After testing at baseline (peak power, Wpeak, and average power, Wmax) in order to set training intensities, subjects were asked to train twice a week for 4 weeks. Each session consisted of 8 to 14 sets of 5 repetitions at progressively increasing fractions of the maximum power output: in week 1 70% of Wmax, 90% of Wmax in week 4. Participants were provided a visual feedback using D.Soft, the D11 dedicated software, so that they were allowed to see and adjust in real-time their power output during the training sessions. Participants were allowed to rest for 30 seconds between sets. Analysis was carried out using Prism 6 Statistical Software (paired T-test), significance was set at 0.05.

RESULTS

At baseline Wpeak was 737.1±423.9 W (mean ± standard deviation). After 8 sessions over 4 weeks of high intensity intermittent isoinertial training Wpeak significantly (p=0.0003) increased from 737.1±423.9 W to 1063.7±459.8 W, mean of differences 486.9 W, 95% CI 299.4 to 674.4 W) and Wmax significantly (p=0.0010) increased from 521.2±297.3 W to 861.3±383.3 W, mean of differences 448 W, 95% CI 244.3 to 651.7.

DISCUSSION

Our results show that a 4-week low-volume (twice a week) isoinertial training programme performed at submaximal intensities (80% Wmax) is useful to enhance power output. Further research is needed to clarify the mechanisms of adaptation.

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Desmotec Articles (5)

Variations of muscle activity patterns in free weight *versus* flywheel resistance front squat: a pilot study

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Conclusion

The flywheel front squat showed an increased muscular activity, mainly in eccentric phase of the exercise, in agreement with previous results.

The muscle activation pattern analysis did not show an increase in spine muscles activity, suggesting the absence of increased risk for spine overload; it could confirm the potential utility of flywheel resistance in resistance training even in rehabilitation settings and/or in early phases of training.

Further studies are required to evaluate the role of flywheel exercise in a rehabilitation program.

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