THE EFFECTS OF CONCENTRIC TRAINING AT TWO ANGULAR VELOCITIES ON TRAINED AND UNTRAINED LIMB STRENGTH GAINS

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Original Scientific paper

Abstract

This study aimed to determine whether the non-dominant unilateral concentric isokinetic knee extensors and flexors strength training at 60°/s and 180°/s results in speed specific strength gains in trained and untrained limb. Twenty three female kinesiology students (age: 21±2 years; BH: 168±5 cm; BW: 62±8 kg) were divided to slow training (STG) or fast training (FTG) group. Both groups performed a 4-week non-dominant unilateral concentric isokinetic knee extensors and flexors strength training at 60°/s and 180°/s, respectively. Statistically significant strength gains occurred in trained and untrained extremity at both angular velocities in STG, while FTG improved only trained extremity strength at both angular velocities. Repeated measures ANOVA showed there were no statistically significant differences between trained extremity effect sizes, while statistically significant differences occurred between the groups in lower velocities strength gains at untrained extremity. Unilateral concentric isokinetic training causes general and speed specific strength gains in trained and untrained extremity, respectively. Fast group showed speed specific strength gains in untrained limb.

Key words: Knee, Peak Torque, Speed Specificity, Contralateral effects

Introduction

Resistance training is one of the most widespread and studied types of exercise. In general, it includes systematic application of submaximal and maximal contractions aimed at overcoming various types of Regardless of the resistance. aim, the methodological approach, type of contractions or the body part involved, this type of exercise enhances muscle contractile properties and increases strength and power: thus, its use is immense in all fields of applied kinesiology (Marković, 2004).

The strength gain is primarily determined by two aspects, the morphological characteristics and neural activation of the muscle (Zhou, 2003). Previous studies predominantly associated isokinetic training with neural adaptation (Akima et al., 1999). This type of adaptation can influence the number of recruited motor units, each unit's firing frequency, etc (Enoka, 1997). Therefore, this type of training improves muscle activation and control (Narici et al. 1989) and enhances neural drive (Aagard et al., 2002).

Additionally, resistance training is speed specific (Morissey et al., 1995; Kraemer et al., 2002). Previous researchers noted this type of specificity at trained (Coyle et al., 1981; Coburn et al., 2006) and untrained (Farthing and Chilibeck, 2003; Munn et al., 2005) limb, during isotonic (Pousson et al. 1999; Westcott et al., 2001), isokinetic eccentric (Ryan et al., 1991; and Farthing and Chilibeck, 2003a) and concentric (Coburn et al., 2006) contractions.

Some studies aimed at evaluating speed specificity at trained muscle group had small sample sizes, for example, the one by Narici et al. (1989) included 4 subjects, one experimental group (Timm, 1987), evaluating only one contraction type/speed, or even, in some cases (Prevost i sur., 1999), compared lower angular velocities (30°/s) with nine times faster (270°/s).

Problem and aim

There were no studies conducted with an aim to evaluate speed specificity using solely concentric isokinetic training.

This study aimed to determine whether the nondominant unilateral concentric isokinetic knee extensors and flexors strength training at 60°/s and 180°/s results in speed specific strength gains in trained and untrained limb.

Methods

Sample

Twenty three female kinesiology students (age: 21 ± 2 years; BH: 168 ± 5 cm; BW: 62 ± 8 kg) volunteered to participate in the study. Participants with lower extremity injury documented within the last two years and/or the ones enrolled in systematic lower extremity strength training 6 months prior to this study were excluded. After eligibility determination, participants were randomly divided into slow velocity (60° /s) training (STG) and fast velocity (180° /s) training (FTG) groups which consisted of twelve and eleven subjects, respectively. Written consent was obtained for each

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participant whilst they were asked to refrain from arbitrary lower extremity strength training during the course of the study which was approved by the University's Human Ethics Board. The final sample consisted of participats who attended a minimum of 85% of the experimental procedure.

Description of experimental procedure

Initial evaluation was performed after the randomisation procedure. During the training period, both groups maintained their normal physical activity. Additionally, both STG and FTG group performed a 4-week non-dominant unilateral concentric isokinetic knee extensors and flexors strength training at 60°/s and 180°/s, respectively. Isokinetic training was performed at a 100% effort level. The number of repetitions in each series and the number of series was set in a way (Table 1) that progressively increased total work performed weekly. Total work was equal between the groups.

Maak		ST	G	FTG		
vveek	Training session	Series	Reps	Series	Reps	
	1	2	5	2	7	
1	2	3	5	3	7	
	3	3	5	3	7	
	1	3	6	3	8	
2	2	3	6	3	8	
	3	3	6	3	8	
	1	4	5	4	7	
3	2	4	5	4	7	
	3	4	5	4	7	
4	1	4	6	4	8	
	2	4	6	4	8	
	3	4	6	4	8	

Table 1. Experimental procedure performed by two experimental groups

Instrumentation

The isokinetic peak torque was assessed using a Biodex System 3 isokinetic dynamometer (Biodex, Shirley, USA). The highest single repetition peak torque among all contractions for a given set served as a representative score for the statistical analysis. Biodex torque values have ICC above 0,95 (Drouin et al., 2004).

Isokinetic strength testing protocol

Before testing, a warm-up procedure consisting of cycling (5 minutes), dynamic stretching (3-5 minutes) and three sub-maximal and one maximal concentric isokinetic contraction was carried out.

All measurements were performed bilaterally using the seated position. The lateral femoral condyle was aligned with the dynamometer's axis whilst the stabilisation straps were placed over the chest, hips and distal thigh at tested leg. Participants kept their hands crossed on their chest during the testing. Gravitational correction was applied to the direct measures of leg extensions at leg angle of 30° and the range of motion was set at 90°. Participants were instructed to perform at a 100% effort and their dominant leg was always tested first. The dominant leg was defined as the leg which the participants preferred using for kicking the ball (Weir et al., 1997).

Knee extensors and flexors peak torque was tested during concentric-concentric contractions at speeds of 60°/s and 180°/s with 5 repetitions. Participants had one minute rest between the two testing speeds.

Data and statistical analyses

Peak torque values at 60°/s and 180°/s served as dependent variables. Normality of the findings was analysed using the Kolmogorov Smirnov (KS) test. Initial testing between-group differences were determined using MANOVA. Repeated measures ANOVA was used to compare effect sizes. Changes were analysed using paired samples T-test. The statistical significance level was set at p<0.05.Two columns, Verdana 9 normal, space

Results and discussion

Kolmogorov-Smirnov test results indicated that none of the variables deviate significantly from the expected normal distribution (p>0.20). Initial measures MANOVA (table 2) showed no betweengroup difference.

MANOVA					
Wilks' A	F	Sig			
.918	.191	.989			
-					

Table 2. Initial measurement MANOVA

Table 3 shows significant strength gains in trained and untrained extremity at both angular velocities in STG. Furthermore, the FTG improved trained extremity strength at both angular velocities, while the contralateral effects were not significant.

As shown in table 4, there were no significant differences between trained extremity effect sizes, while significant differences occurred between the groups in lower velocities strength gains at untrained extremity.

Many previous studies have been conducted with an aim to evaluate strength training effect size at trained and/or untrained extremity and to evaluate its speed specificity at trained or untrained extremity, singularly. The difference of this and previous studies is that this study aimed to evaluate unilateral isokinetic concentric strength training speed specificity in both trained and untrained extremities at two different velocities.

Trained limb strength gains were statistically significant at both angular velocities (p < 0.05). It is noteworthy that STG effect sizes were insignificantly larger than those achieved by the FTG.

The findings of this study are in agreement with earlier studies, which demonstrated that training at

	Vor	STG				FTG					
	Vai	Initial	Final	Mean	change	Sig	Initial	Final	Mean	change	Sig
	E60	145.9±36.3	172.1±31.3	26.61	18.3	0.00	148.1±18.3	162.1±24	14.09	9.5	0.00
Trained	E180	96.5±18.7	115.4±17.9	18.62	19.3	0.00	98.9±13.5	113.5±12.6	14.6	14.8	0.00
	F60	75.3±19.4	94.9±15.8	19.57	25.9	0.00	77.8±15	91.1±16.4	13.29	17.1	0.00
	F180	56.5±15.5	69.6±15.2	13.12	23.2	0.00	58.3±13.7	73.4±11.6	15.11	25.9	0.00
p	E60	147.9±33.3	169.4±30.2	21.47	14.6	0.00	152.9±16.8	157.7±20.9	4.83	3.1	0.26
aine	E180	96.9±20.6	112.9±16.5	16.03	16.5	0.00	99.2±9.1	110±11.9	10.87	10.9	0.00
ntra	F60	79.7±20.5	93.1±17.4	13.39	16.8	0.00	81.3±15.6	85.2±14.2	3.95	4.9	0.11
N	F180	60.1±17.8	67.8±16.4	7.77	12.9	0.00	60.3±13.5	66.5±11.7	6.19	10.3	0.03
E60 - leg extension, angular velocity of 60°/s; E180 - leg extension, angular velocity of 180°/s; F60 - leg flexion, angular											
	velocity of 60∘/s; F180 - leg flexion, angular velocity of 180∘/s										

Table 3. Mean \pm SD and paired samples t-test for the initial and final state of peak torque at knee extensor and flexor muscles (Mean values are in Nm)

lower (Kanehisa & Miyashita, 1983; Farthing & Chilibeck, 2003a) and higher (Adeyanju et al., 1983; Garnica, 1986) angular velocities results in general strength gains. There are also studies with opposite conclusions. For example, some stated that concentric isokinetic strength training is speed specific at low (Coyle et al. 1981), while others (Caiozzo et al., 1931; Coburn et al., 2006) claimed this happens only at high angular velocities. The difference between this and previous studies that have proven opposite could be due to the angular velocities. Those studies included angular velocities faster than 200°/s, thus amplifying slow/fast velocity ratio. In this study, slow/fast ratio was 1:3 (60°/s:180°/s), while, for example, in Ewing et al. (1990) study, this ratio was 1:4 (60°/s:240°/s). Furthermore, the ratio was 1:9 (30°/s:270°/s) in a study by Coburn et al. (2006). Although differences between strength gains were not significant, based on the findings of previous authors and significance levels (p=0.073 & p=0.057), it can be hypothesized that this difference would be significant if the FTG trained at angular velocity greater than 200°/s. Accordingly, additional single or even multiple groups training at different angular velocities could determine the range in which isokinetic strength training speed specificity occurs exactly. A study that aimed to evaluate this range (Ewing et al., 1990) showed that slow (60°/s) and fast (240°/s) training groups had speed specific strength gains, but both improved at 180°/s. Similar discrepancies between conclusions can be found in studies evaluating isotonic training. While some confirmed speed specificity (Schuenke et al., 2012), others stated that it does not occur (Pereira et al., 2007).

Limb	Variable	RepeatedMeasures ANOVA					
LIIID	vallable	Wilks' A	F	Sig			
Trained	E60	.756	3.864	.073			
	E180	.916	1.105	314			
	F60	.731	4.422	.057			
	F180	.877	1.686	.219			
Intrained	E60	.659	6.210	.028			
	E180	.840	2.284	.157			
	F60	.696	5.248	.041			
	F180	.984	.189	.671			

Table 4. Repeated measures ANOVA

Although this study did not prove speed specificity, strength gains differences and their statistical significance levels point out the necessity of conducting complex experimental designs with more groups and more angular velocities in order to determine how and to what extent the effects are transferred to other angular velocities.

When it comes to the untrained limb, i.e. contralateral training effects, it is evident that STG recorded statistically significant strength gains at both angular velocities, while the FTG had significant strength gains solely at higher velocity. Results also show that contralateral strength gains, measured at slower angular velocity, differ statistically significant between STG and FTG.

Contralateral strength gains ranging from 3% to 16% do not differ from earlier studies. In fact, Munn et al., (2004) reported that the contralateral training effects from the 17 previous studies ranged from -2.7% to 21.6% of the initial measurement. The results of this study showed larger contralateral strength gains after slow training. It is also shown that slow unilateral concentric isokinetic training strength gains transferred to non-trained extremity at all angular velocities and that fast unilateral concentric isokinetic training enhances contralateral torque production only at fast angular velocity. Considering the significant difference between strength gains at different velocities, it is evident that fast unilateral concentric isokinetic training results in speed specific contralateral strength gains.

A study that showed somewhat different results regarding speed specific strength gains and suggested (p=0.08) that fast isokinetic training causes greater effects than slow, conducted by Munn et al. (2005), evaluated eccentric isokinetic training at different velocities. Although some differences between this and the previously mentioned study exist, these results confirmed findings made by Farthing and Chilibeck (2003a), who suggested an insignificant trend for training at lower speeds to produce a greater contralateral effect. Although concentric training did not result in significant strength gains, their results show that concentric elbow flexors strength training causes general strength gains at slow and specific at high angular velocities. The reason behind these

differences can be found in a study by Seger et al. (1998) and Duncan et al. (1989) who concluded that eccentric isokinetic exercise has highly specific strength training effects while the concentric mode has less specific training effects.

Although not measured directly, it is likely that neural adaptation could explain the strength augmentation (Narici, 1989; Kidgell, 2010) because, in this relatively short training period, the progress in torque development cannot be attributed to the change in muscle size (Zhou, 2003). It has also been suggested that the neural adaptation occurs differently at various training conditions (Behm & Sale, 1993; Cutsem et al., 1998). For detailed possible mechanisms, see review by Carroll et al. (2006).

The results of this study can further help both strength and conditioning coaches and clinicians because they suggest that slow velocity isokinetic training indicates no speed specificity in strength gains, thus improving general strength, both in trained and untrained extremity.

Conclusion

Unilateral concentric isokinetic training at different angular velocities (60°/s and 180°/s) causes general strength gains in trained and speed specific strength gains in untrained extremity. STG training effects were insignificantly higher at slow testing speed showing a trend towards speed specificity. Fast group showed general strength gains at slow and speed specific at fast angular velocities in untrained limb.

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UČINCI KONCENTRIČNOG TRENINGA NA DVIJE KUTNE BRZINE NA JAKOST TRENIRANOG I NETRENIRANOG EKSTREMITETA

Sažetak

Cilj ove studije je bio ustanoviti da li unilateralni koncentrični izokinetički trening opružača i pregibača koljena pri brzinama od 60°/s i 180°/s rezultira povećanjem jakosti treniranog i netreniranog ekstremiteta specifičnim s obzirom na brzinu. Dvadeset i tri studentice kineziologije (Starost: 21±2 godina; TV: 168±5 cm; TM: 62±8 kg) su podijeljene u sporu izokinetičku i brzu izokinetičku skupinu. Obje skupine su učestvovale u četverotjednom unilateralnom koncentričnom izokinetičkom treningu opružača i pregibača koljena nedominantne noge pri brzinama od 60°/s i 180°/s. Statistički značajno povećanje jakosti je primijećeno pri testiranju na obje kutne brzine kod treniranog i netreniranog ekstremiteta u sporoj skupini, dok je u brzoj skupini isto zabilježeno isključivo kod treniranog ekstreminteta. Rezultati ANOVA-e ponovljenih mjerenja nisu bili statistički značajni kada je u pitanju razlika između veličine učinaka zabilježenih kod treniranog ekstremiteta, dok su se statistički značajne razlike javile između skupina pri nižoj brzini testiranja netreniranog ekstremiteta. Unilateralni koncentrični izokinetički trening rezultira općim povećanjem jakosti kod treniranog i specifičnim na brzinu kod netreniranog ekstemiteta. Učinci na netrenirani ekstremitet specifični s obzirom na brzinu su primijećeni isključivo kod brze izokinetičke grupe.

Ključne riječi: Koljeno, Vršni moment sile, Brzinska specifičnost , Kontralateralni učinci

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