DIFFERENCES IN THE SIZE OF UNILATERAL ISOKINETIC EFFECTS WITH REGARD TO ANGULAR SPEED OF TRAINING*

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Abstract

This study aims to define existence of differences in the size of effects of development of peak torque of knee extensor and flexor of a dominant leg between two groups which implemented isokinetic training with different angular speed. 45 female students were divided into three groups, two experimental and one control group. Maximum strength of dynamic knee stabilizers was tested on an isokinetic apparatus (Biodex 3) with angular speed of 60°/s and 180°/s. The first group conducted an additional isokinetic training of a dominant leg with angular speed of 60°/s, while the second group conducted the same training with angular speed of 180°/s in the period of four weeks. Obtained results lead to the conclusion that a concentric isokinetic training with angular speed of 60°/s produced greater effects (absolutely and relatively expressed) on development of maximum strength of dynamic knee stabilizers then an isokinetic training conducted with angular speed of 180°/s in testing with both angular speeds.

Key words: *training, strength, dominant leg, dynamic knee stabilizers*

Introduction

In scientific literature Isokinetics is first mentioned as a diagnostic method and only later as an individual or additional training method for development of strength. Thistle et al. (1967) introduced the concept of isokinetic exercises into the scientific literature and defined that isokinetic resistance had several advantages in regard to other ways of exercising. The most significant advantage is that a muscle group can be exercised to its maximum potential along the whole scope of movement of a joint. Since speed can be adjusted on an isokinetic dynamometer from 0 to 450 degrees in a second during a training, the objective of this study is to define a size of difference of effects of such a training in regard to angular speed of exercising with 60°/s or 180°/s. An additional benefit of application of these angular speeds is a wide application of this range, which was examined in many studies (Ghena et al. (1991), Mangine and Noyes (1992). These angular speeds were also applied by many researchers in order to measure strength of dynamic knee stabilizers (Kellis et al. 2001; Dauty et al. 2003; Ergun et al. 2004; Kazazović at al. 2007, Kovačević 2010). Pursuant to these information, this study will attempt to define which one out of the most frequently applied speeds, 60°/s or 180°/s, provides better training effects. Namely, the intention is to define existence of differences in the size of effects on development of peak torque of the knee extensor and flexor of a dominant leg between two groups which performed isokinetic trainings with the mentioned angular speed.

Methods

Examinees sample:

Population of physically active women, 45 female sport faculty students, was divided into three groups with a random selection method: the first – experimental group (n = 15), the second experimental (n = 15) and control group (n = 25). The population included physically active women between the age of 19 and 25. None of the selected examinees could have a history of injuries of lower limbs in the last two years.

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Variables sample:

Variables for an assessment of the knee extensor and flexor strength with an isokinetic dynamometer:

1. KE60PT - Knee – extension – 60°/s – peak torque
2. KF60PT - Knee – flexion – 60°/s – peak torque
3. KE180PT - Knee – extension – 180°/s – peak torque
4. KF180PT - Knee – flexion – 180°/s – peak torque

Experimental procedure description

During this training period the groups performed physical activities related to a program of regular classes at the Sport Faculty, but the experimental groups also performed an additional isokinetic training of a dominant leg.

Experimental group 1 (slow) performed knee trainings on a Biodex isokinetic dynamometer, 3 times weekly, with angular speed of 60°/s.

Experimental group 2 (fast) performed knee trainings on a Biodex isokinetic dynamometer, 3 times weekly, with angular speed of 180°/s.

Control group (3) acted according to a regular curriculum and a practical training program of a year of study attended by a full time student.

A number of series and a number of repetitions in series is set in a way that performed work is increased progressively (total work) from week to week. A pilot measuring defined that the ratio of worked performed in one repetition with 60 and 180 °/s in stretching and flexion of a knee is 1,33. Repetitions for slow and fast group are calculated in this way. This means that according to this calculation both groups would perform equal quantity of mechanical work – they would have the identical training volume.

Data processing methods

Basic central and dispersion parameters were calculated with descriptive statistics:

Data processing was done with statistical packages IBM SPSS 19,0 for Windows and STATISTICA 9.0. One applied univariate analysis of variance (ANOVA) to difference variables (final measuring result minus initial measuring result) for defining of effects of the implemented experimental procedure. A level of statistical significance was set to $p < 0.05$.

Results

Quantitatively expressed effects of the implemented isokinetic training for the first "slow" (60°/s) experimental group are visible in an increase of average result of peak torque of knee extensor of 25,9 Nm or ~ 18 %, between the initial and the final measuring.

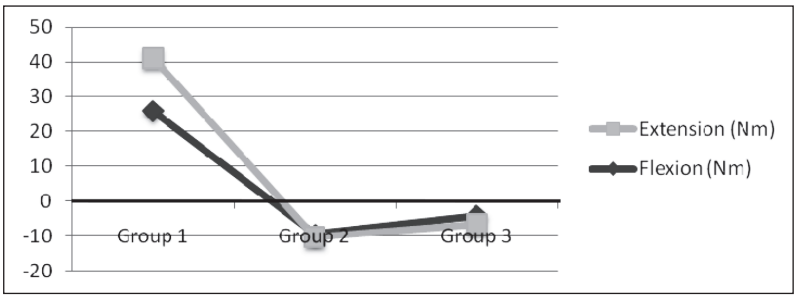
Table 1. Statistical significance of differences in realized effects among group

Multiple Comparisons: Dependent Variable: Knee – Extension – 60°/s						
		Mean Difference (I-J)	**Std. Error**	**Sig.**	**95% Confidence Interval**	
GROUP	**GROUP**				**Lower Bound**	**Upper Bound**
1	**2**	**35.2667(*)**	5.6017	**.000**	21.2979	49.2354
	3	**30.0867(*)**	5.6017	**.000**	16.1179	44.0554
2	**1**	-35.2667(*)	5.6017	.000	-49.2354	-21.2979
	3	-5.1800	5.6017	1.000	-19.1488	8.7888
3	**1**	-30.0867(*)	5.6017	.000	-44.0554	-16.1179
	2	5.1800	5.6017	1.000	-8.7888	19.1488

Negative effects or a decrease of average results are visible with second experimental group for about 4% , or 9,53 Nm. Results of the final measuring for the control group is 4,2 Nm or ~ 3%, which is 5,3 Nm less in regard to the decrease of results of the second experimental group.

Table 2. Statistical significance of differences in realized effects among groups

Multiple Comparisons: Dependent Variable: Knee – Flexion – 60°/s						
		Mean Difference (I-J)	**Std. Error**	**Sig.**	**95% Confidence Interval**	
GROUP	**GROUP**				**Lower Bound**	**Upper Bound**
1	**2**	**15.9800(*)**	3.6480	**.000**	6.8831	25.0769
	3	**17.6000(*)**	3.6480	**.000**	8.5031	26.6969
2	**1**	-15.9800(*)	3.6480	.000	-25.0769	-6.8831
	3	1.6200	3.6480	1.000	-7.4769	10.7169
3	**1**	-17.6000(*)	3.6480	.000	-26.6969	-8.5031
	2	-1.6200	3.6480	1.000	-10.7169	7.4769



Graph 1. Graphical illustration of effects among groups measured with 60°/s

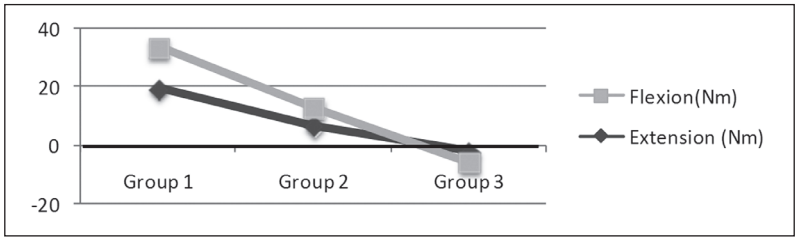
Namely, the increase of average result of the first experimental group is 15,2 Nm or ~ 20%. Analyzing effects of the second experimental group to the knee flexor strength measured at angular speed of 60°/s we see similarities with results obtained for the knee extensor at the same angular speed. Negative effects and the decrease of average results of this group is 0,8 Nm. the control group has the decrease in results of 2,4 Nm or ~ 3%.

Table 3. Statistical significance of differences in realized effects among groups

Multiple Comparisons: Dependent Variable: Knee – Extension – 180°/s						
		Mean Difference (I-J)	**Std. Error**	**Sig.**	**95% Confidence Interval**	
GROUP	**GROUP**				**Lower Bound**	**Upper Bound**
1	**2**	12.8933(*)	4.0540	.008	2.7840	23.0026
	3	**21.6400(*)**	4.0540	**.000**	11.5307	31.7493
2	**1**	-12.8933(*)	4.0540	.008	-23.0026	-2.7840
	3	8.7467	4.0540	.110	-1.3626	18.8560
3	**1**	-21.6400(*)	4.0540	.000	-31.7493	-11.5307
	2	-8.7467	4.0540	.110	-18.8560	1.3626

Table 4. Statistical significance of differences in realized effects among groups

Multiple Comparisons: Dependent Variable: Knee – Flexion – 180°/s						
		Mean Difference (I-J)	**Std. Error**	**Sig.**	**95% Confidence Interval**	
GROUP	**GROUP**				**Lower Bound**	**Upper Bound**
1	**2**	7.6533(*)	2.9222	.037	.3662	14.9404
	3	**17.6667(*)**	2.9222	**.000**	10.3796	24.9538
2	**1**	-7.6533(*)	2.9222	.037	-14.9404	-.3662
	3	**10.0133(*)**	2.9222	**.004**	2.7262	17.3004
3	**1**	-17.6667(*)	2.9222	**.000**	-24.9538	-10.3796
	2	-10.0133(*)	2.9222	**.004**	-17.3004	-2.7262



Graph 2. Graphical illustration of effects measured among groups with 180°/s

The first experimental group that performed an isokinetic training of the knee extensor at 60°/s, showed the increase of average results of 19,6 Nm or ~ 21%. The second experimental group which implemented an isokinetic knee training at angular speed of 180°/s showed an increase of results regarding peak torque of the knee extensor measured at the same angular speed of 6,6 Nm or ~ 6%. The first experimental group shows an increase of results of maximum peak torque of the knee flexor measured at angular speed of 180°/s in the final measuring of 14,1 Nm or ~ 25%. The second experimental group achieved the increase of 6,4 Nm or ~ 10%.

Discussion an conclusions

Comparing an analysis of results obtained from the implementation of a 4-week isokinetic training with two experimental groups which performed the mentioned training with two different angular speeds with results of the control group we obtain:

Analysis of effects of applied isokinetic programs measured at "low" angular speeds

Quantitatively expressed effects of the implemented isokinetic training for the first "slow" (60°/s) experimental group are visible in an increase of average result of peak torque of knee extensor of 25,9 Nm or ~ 18 %, between the initial and the final measuring. It was logical to expect these results due to specificities of the implemented isokinetic training. It is known that effects of a training are the best in an exercise that is also applied as a training asset and as a test for evaluation of effects of so called "specificity of training" (Sale and MacDougal, 1981). If we analyze results of the second "fast" (180°/s) experimental group at the same variable, we reach indicators that are not in accordance with presumptions preceding the implemented experimental program. Namely, the second experimental group performed an isokinetic training of the knee extensor at "higher" angular speed of 180°/s, but it was logical that they would achieve positive transformation effects measured at a lower angular speed. However, negative effects or a decrease of average results are visible with this experimental group for about 4% , or 9,53 Nm. These results are not in accordance with results of previous researches (Coyle et al. 1981) which conclude that training at higher angular speed has a tendency to increase strength to and below training speed. Precisely saying, a decrease of results of the final measuring for the control group is 4,2 Nm or ~ 3%, which is 5,3 Nm less in regard to the decrease of results of the second experimental group. Similar results regarding the size of changes are visible in measuring of peak torque of the knee flexor at angular speed of 60°/s. Namely, the increase of average result of the first experimental group is 15,2 Nm or ~ 20%. Analyzing effects of the second experimental group to the knee flexor strength measured at angular speed of 60°/s we see similarities with results obtained for the knee extensor at the same angular speed. Negative effects and the decrease of average results of this group is 0,8 Nm. Different from results of the knee extensor, the control group has a greater decline of results in regard to the second experimental group. Quantitatively expressed, the control group has the decrease in results of 2,4 Nm or ~ 3%. We see that there are statistically significant differences in training effects between the first and the second experimental group, and the first experimental group and the control group regarding the knee extensor and flexor.

Analysis of effects of applied isokinetic programs measured at "high" angular speeds

The first experimental group that performed an isokinetic training of the knee extensor at 60°/s, showed the increase of average results of 19,6 Nm or ~ 21%. These results can be explained with the fact that concentric isokinetic training at lower angular speed, in our case 60°/s, is so unspecific that it caused a significant increase of maximum strength of the knee extensor measuerd at angular speed higher than 180°/s.

The second experimental group which implemented an isokinetic knee training at angular speed of 180°/s showed an increase of results regarding peak torque of the knee extensor measured at the same angular speed of 6,6 Nm or ~ 6%. Therefore, the applied isokinetic training of a concentric character at higher angular speed caused an increase of maximum strength of the knee extensor measured at angular speed of 180°/s, but those effects are significantly less in regard to the effects of the first experimental group. Quantitatively speaking, the control group shows the decrease of

the results in the applied period of time of 2,1 Nm or ~ 2%. Differences between the first and the second experimental group are not statistically significant but have a significance trend p=0,008 while the second experimental group does not significantly differ from the control group statistically. These indicators only confirm our conclusion that isokinetic knee training at lower speeds is more dominant than the same at higher angular speeds.

An analysis of results of effects of increasing of maximum peak torque of the knee flexor measured at angular speed of 180°/s shows the same trend which was seen with the knee extensor at the same angular speed. The first experimental group shows an increase of results of maximum peak torque of the knee flexor in the final measuring of 14,1 Nm or ~ 25%.

The second experimental group achieved the increase of 6,4 Nm or ~ 10% in measuring of maximum flexor strength at angular speed of 180°/s. We again see that the difference between the first and the second experimental group in effects is 15% to the advantage of the first group.

The control group shows the decrease of results of 3,6 Nm or ~ 6%, which was also the case with extensors at this angular speed. Multiple comparisons among the groups on a basis of variables of knee flexion at angular speed of 180°/s show that there are statistically significant differences in training effects between the first experimental and the control group.

We can draw a conclusion from the obtained results that unilateral concentric isokinetic training of the two experimental groups, with different angular speed, produced positive transformational effects on maximum strength of the knee extensor and flexor expressed through peak torque. This conclusion is completely supported with results of the first experimental group, which performed an isokinetic training of dynamic knee stabilizers at "low" angular speed of 60°/s, which caused positive and statistically significant effects in all measurings at lower (60°/s) and higher (180°/s) angular speeds. On the other hand, the second experimental group which performed the same type of training at "high" angular speed of 180°/s showed positive effects only in measuring of maximum peak torque of the knee extensor and flexor in testing at a training angular speed while measuring at low angular speed show negative effects and a decrease of maximum peak torque of dynamic knee stabilizers. Generally, it can be concluded that concentric isokinetic training at angular speed of 60°/s produced, both absolutely and relatively expressed, greater effects on development of maximum strength of dynamic knee stabilizers than isokinetic training implemented at angular speed of 180°/s in testing with both angular speeds.

References

1. Coyle, E.F. et al. (1981). *Specificity of power improvements through slow and fast isokinetic training.* Journal of Applied Physiology, 51: 1437-1442.
2. Dauty, M., Potiron-Josse, M., & Rochcongar, P. (2003). *Identification of previous hamstring muscle injury by isokinetic concentric and eccentric torque measurement in elite soccer players*. Isokinetic and Exercise Science 11(3): 139-144.
3. Ergun, M., Islegen, C., & Taskiran, E. (2004). *A cross-sectional analysis of sagittal knee laxity and isokinetic muscle strength in soccer players*. International Journal of Sports Medicine 25(8): 594-598.
4. Ghena, D.R., Kuth, A.L., Thomas, M., & Mayhew, J. (1991). *Torque characteristics of the quadriceps and hamstring muscles during concentric and eccentric loading.* Journal of Orthopaedic and Sports Physical Therapy 14: 149-154.
5. Kellis, S., Gerodimos, V., Kellis, E., & Manou, V. (2001). *Bilateral isokinetic concentric and eccentric strength profiles of the knee extensors and flexors in young soccer players*. Isokinetic and Exercise Science 9(1): 31-39.
6. Kovačević, E. (2009). *Effects of concentric isokinetic training at various angular speeds on maximum and explosive strength of physically active women*. Master's thesis, Faculty of Sport and Physical Education, University of Sarajevo.
7. Mangine, R., & Noyes, F. (2001). *Functional performance testing following knee ligament injury.* Physical Therapy in Sport, Volume 2, Issue 2, Pages 91-105 N.Clark.
8. Sale, D.G., & MacDougal, J.D. (1981). *Specificity in strength training: a review for the coach and athlete*. Canadian Journal of Applied Sport Science, 6(2): 87-92
9. Thistle, H.G., Hislop, H.J., Moffroid, M., & Lowman, E.W. (1967). *Isokinetics contraction: a new concept of resistive exercise*. Archives of Physical Medicine and Rehabilitation, 48:279-282