

## THE EFFECTS OF ISO-KINETIC EXERCISE PROGRAM ON THE KNEE FLEXING STRENGTH

Elvir Kazazović, Vahida Kozić, Erko Solaković, Lejla Šebić-Zuhrić

*Faculty of Sport and Physical Education Sarajevo*

*Original scientific paper*

### **Abstract**

*The goal of this research is the study of the maximum force moment, the full function, as well as the average flex muscle strength of the dynamic knee stabilizers. Fifteen elite soccer players of the first division and thirteen amateur soccer players participated in this study. The researcher subjects who participated in this research are University of Sport and Physical Education, Sarajevo, students (40 students total). The estimate of changes observed based on iso-kinetic exercises (concentric and eccentric) on muscle stabilizers of the knee was performed on all 40 subjects. Research subjects were divided in two groups: experimental and control. The maximum strength of dynamic stabilizers of the knee has been tested on iso-kinetic instrument (machine Biodex 3) at degree speeds between 60 degrees/s and 180 degrees/s. In addition to their regular classes at the University, the experimental group spent in additional exercise programs on Biodex 3 machines, for 12 weeks, 3 times a week. The results will show that the additional iso-kinetic exercise program on the said machines effectively improve the strength of the flex muscles of the knee.*

**Keywords:** *knee muscles, iso-kinetic training, effects*

### **INTRODUCTION**

The demands of modern training in elite sports more and more ask for reaching better effects in as little time of training as possible, as well as the application of training methods that enable reaching hypotheses of specific advancements of athletes in different disciplines. Thus far, research shows that there was an absence of iso-kinetic training in the active athletes' training cycles. This study is concentrated on the program of iso-kinetic training for strengthening knee flexors. Moreover, different authors' reports (Brown, Le, et. al. 1994, Clarke, R., et al. 1998) show that the strength of lower extremity flexors is decreasing in relation to extensors, which lead to a less than ideal comparison between those two groups of muscles.

The iso-kinetic diagnosis represents a technologically advanced treatment for the evolution of relevant parameters of muscular-skeletal systems (Schlumberger i sur., 2006) (Zakas, 2006). The functional decrease of flexors in comparison with the extensors can be attributed to several problems. First, there is an increase in flexor rupture possibility. Even though there exist a few different variances of instruments and protocols for

joint flexor treatments that are used (fitness machines), no machine has shown itself ideal for a fast development of this muscle group, nor for an estimate measurement between flexors and extensors. A combination of eccentric and concentric contractions of muscles during training on iso-kinetic instruments results in more strength when compared to training protocols involving other instruments (fitness machine, etc.).

This study attempted to affirm the effect of iso-kinetic training on the strength of the knee flexor muscles. The analysis of the research subjects in two timing spots (t- test and discriminative analysis) affirmed the differences in variables in two research subject groups, which gives an objective picture of the program effects.

### **METHODS**

*Iso-kinetic testing:* The research involves 40 subjects, students of University of Sport and Physical Education in Sarajevo (average age  $21.1 \pm 3.6$ ), divided into an experimental group (N=20), which besides the regular class attendance also attended additional training on Biodex 3 machine, and a control group (N=20), which only attended the regular

classes in athletics, handball, and basics of motorics.

The study was performed at the Institute of Sport in Sarajevo. Before the initial testing, the subjects spent two hours learning about the testing instruments and exercise protocols; they also had a warming up period, involving stretching lower extremity muscles and exercises on the bicycle machine.

The power of knee flexors was tested in the sitting position on the Biodex chair, where the subjects were strapped with belts around the stomach and thigh, in order to stabilize the area above the knee. The settings of tibial pads, dynamo-metric heights, and angles of the seats were recorded in order to maintain reliability and reproduction during the test.

Iso-kinetic testing protocol of knee flexors' strength was performed at  $60^\circ / s$  and  $180^\circ / s$ , with 5 repetitions on both speeds and a pause of 30s between repetitions. The same procedure was produced for the left and right leg (Madsen et al., 1996, Gleeson et al., 1996). These angular velocities were used by many researchers in order to measure the force of dynamic knee stabilizers (Kellis, Gerodimos, Kellis, Mano 2001; Dauty, Poriton-Joss, Rochcongar 2003; Ergun, Islegen, Taskiran 2004; Kazazovic, Radja, Dervisevic, Smith 2007). Knee joint movements were limited to values from  $0^\circ$  to  $90^\circ$ . For further statistical processing, the automatically calculated values of maximum torque, total work, and average power of flexors on both speeds were recorded. Both groups were tested again after 12 - week training period using the same procedures iso-kinetic testing.

With the iso-kinetic measurements of the knee muscles, the following variables were gathered:

*The maximum strength of the knee flexor muscles (speed  $60^\circ / s$ )*

FLXLEF60 (Nm) - The maximum torque of knee flexors in left leg

FLXRIG60 (Nm) - The maximum torque of knee flexors in right leg

FXLFTW60 (J) - The cumulative work of knee flexors in left leg

FXRGTW60 (J) - The cumulative work of knee flexors in right leg

AVGPLF60 (W) - Average strength of knee flexors in left leg

AVGPRG60 (W) - Average strength of knee flexors in right leg

*The maximum strength of knee flexor muscles (speed  $180^\circ / s$ )*

FLXLEF180 (Nm) - The maximum torque of knee flexors in left leg

FLXRIG180 (Nm) - The maximum strength of knee flexors in right leg

FXLFTW180 (J) - Cumulative work of knee flexors in left leg

FXRGTW180 (J) - Cumulative work of knee flexors in right leg

AVGPLF180 (W) - Average strength of knee flexors in left leg

AVGPRG180 (W) - Average strength of knee flexors in right leg

***The iso-kinetic exercise program.*** The experimental group of subjects had an iso-kinetic program of exercise 3 times a week for 12 weeks, as follows:

Warming up on bicyclogometer and stretching muscles of lower extremities (15 min).

1. 3 series x 4 - 6 repetitions with the left leg on the angular speed of  $60^\circ / s$  with pauses of 30-60s between the series
2. Pause between exercises at various speeds of 3 min.
3. 5 x 4 to 6 repetitions with the left leg on the angular speed of  $180^\circ / s$  with pauses of 30-60s between the series
4. 3 series x 4 - 6 repetitions with the right leg on the angular speed of  $60^\circ / s$  with pauses of 30-60s between the series
5. Pause between exercises at various speeds of 3 min.
6. 5 x 4 to 6 repetitions right foot on the corner speed of  $180^\circ / s$  with breaks of 30-60s between the series.

The training protocol was identical to the testing protocol in the instructions that were given to participants regarding their positions on the Biodex system. During this training period the control and experimental groups engaged in physical activities that are related to the regular classes or practical exercises in these subject areas: athletics, handball, and the introduction to motorics.

***Methods of data processing.*** At the univariate level of data analysis for determining the differences between the groups at initial testing, a T - test for independent samples was

used. The same analysis was also used for determining the difference between groups at final measurements. At the multivariate level of analysis of variables, a discriminative analysis was used. After it was previously established that there are no differences between groups of subjects in the initial testing by discriminative analysis, on the final test the real effects of the two differently treated groups of subjects were affirmed. The criteria for making the conclusions about the effects of the program were the factors of Wilks Lambda, statistical relevance of discriminative functions and values of centroid groups at the initial and final testing.

## RESULTS

For the purpose of analyzing the effects of iso-kinetic exercise program the following statistical procedures were used: descriptive statistics, t-test for determining the difference at univariate level of initial and final measurements, discriminative analysis in the initial and final state. Table 1 shows the results of these statistical analyses of results of experimental and control groups measured in two points in time (initial and final measurement).

An analysis of the results of control and experimental groups in the initial state shows that the subjects do not differ in the initial state. The basic descriptive parameters and statistical relevance of the t - test values showed that there is no statistically significant difference between the two groups of subjects. The results of discriminative analysis for determining the level of significance of differences between groups of subjects confirmed the results of the t - test on the multivariate level. The significance of Box's M-test confirms that subjects belong to the same population, as well as values and significance of Wilks lambda, which confirms that at the initial state there exists no discriminative feature by which the groups of subjects would differ. With the analysis of the initial testing of subjects, we came to the conclusion that there is no difference in the strength of the knee stabilizers in the two groups of subjects. We made the conclusions about the effects of iso-kinetic program on the strength of the knee stabilizers based on the analysis of subject group differences in the final state. The results of T-test at the final measurements showed that the differences in all variables are statistically significant, even to the .00 level, which leads us to the further

	INITIAL MEASUREMENTS					FINAL MEASUREMENTS				
	AD K	AD E	ADK/ADE	p	R Structure	AD K	AD E	ADK/ADE	p	R Structure
FLXLEF60	122.91	118.87	4.03	.645	.129	133.10	164.84	-31.74	.000	<b>.432</b>
FLXRIG60	124.35	119.48	4.86	.568	.161	132.80	165.27	-32.46	.000	<b>.460</b>
FXLFTW60	621.14	574.06	47.08	.401	.237	696.23	870.01	-173.78	.000	<b>.460</b>
FXRGTW60	625.65	596.20	29.45	.574	.158	688.39	875.89	-187.50	.000	<b>.463</b>
AVGPLF60	87.79	86.42	1.36	.860	.049	100.26	126.66	-26.40	.000	<b>.551</b>
AVGPRG60	90.45	89.82	.62	.931	.024	100.83	124.50	-23.66	.000	<b>.448</b>
FLXLEF180	92.95	81.88	11.06	.149	.410	98.15	123.00	-24.85	.000	<b>.526</b>
FLXRIG180	94.03	87.60	6.43	.403	.236	98.66	124.55	-25.89	.000	<b>.526</b>
FXLFTW180	460.87	385.21	75.66	.112	.454	476.60	602.76	-126.16	.000	<b>.474</b>
FXRGTW180	474.62	418.82	55.79	.245	.329	494.49	628.16	-133.66	.000	<b>.485</b>
AVGPLF180	157.19	135.12	22.06	.172	.388	155.29	195.42	-40.13	.001	<b>.408</b>
AVGPRG180	162.74	150.38	12.35	.465	.206	166.88	204.26	-37.37	.001	<b>.371</b>
M (p)					.206					<b>.005</b>
W					.742					<b>.320</b>
p					<b>.680</b>					<b>.000</b>
CK					.560					<b>-1.421</b>
CE					<b>-.590</b>					<b>1.421</b>

Table 1. The basic descriptive characteristics, differences and value of discriminative functions in initial and final measurements (E, K = experimental, control group, AD K i AD E = arithmetic mid points of control and experimental groups, AD = difference of arithmetic mid points, p - level of relevance differences, R - structure of discriminative functions, CK - centroids of control group, EK - centroids of experimental group, M (p) - statistical relevance Box's M-test, W - Wilks Lambda, p - statistical relevance of Wilks Lambda)

evaluation of the procedure. The significance of Box's M-test confirms that there are differences between subjects, as well as the significance of Wilks Lambda, which indicates that in the final measurement there is a discriminative feature by which the two groups of respondents would differ. We have concluded that with the procedures of discriminative analysis a significant discriminative function at the level of significance .00 was noticed. With comparing the values of centroid groups at the initial and final test, it is obvious that there has been a separation of the groups. The conclusion is that at the final measurement, there are differences in the level of measurements, which was not the case in the initial measurement. This fact confirms the presence of practical effects of experimental programs. From the analysis of structure of the discriminative function, it is clear that all variables mainly contribute equally to discrimination of the groups. With its values, the following are worth noticing: the variables of FLXLEF180 - max torque of flexors in the left knee when the speed is 180 °, FLXRIG180 - max torque of knee flexors in the right leg at the speed of 180 °, AVGPLF60 - average power of left knee flexors in 60 °, and FXLFTW180 - cumulative work of left knee flexors at the speed of 180 °, FXRGTW180 - cumulative work of right knee flexors at the speed of 180 °.

## DISCUSSION

By the analyses of the results of initial and final measurements, there have been shown to be significant differences in all parameters tested between control and experimental groups after the training period. The 10-week additional training on Biodex 3 significantly increased the strength of dynamic stabilizers of the knee in the experimental subject group. The largest increase in values of tested variables was in the variables of average left knee flexors strength at 60 °, which leads that the training, in which we worked on the isolated lower limb, impacted positively on the strength of that extremity, and to the values of force amplitudes during the entire duration of the work, which is a better indicator of function of the maximum muscle strength. In the midst of iso-kinetic training, the largest improvement was observed in the lower limb,

which is trained now isolated, made capable by the technology of iso-kinetic training. The values of maximum torque and cumulative work of right and left knee flexors at the speed of 180 ° also show significant progress, which confirms the results of previous research (Agaard, P, et al 1998).

This research shows that a unique training protocol of additional training on the isokinetic instrument, the Biodex 3, produces a significant increase in strength of knee flexors, and its peak torque through the both angular velocities, either at 60 or 180 ° / s. Further analysis in relation to both angular velocities were confirmed by the changes in the strength of knee flexors. The most important observation is the large increase in the value of cumulative work of knee flexors in both legs.

This research shows us that the subjects who had additional training on Biodex 3 through the 12 weeks had a statistically significant increase in the strength of knee flexors, which further verified other research (Kazazovic, Radja, Dervisevic, Smith 2007; Kazazovic E., Tabaković M . 2008; Kazazovic, E., Hadžikadunić A., Kozić V. 2008)) that affirms that the exercise of continuous resistance, which isokinetic dynamometer entails, significantly increases the strength of dynamic knee flexors.

The research results confirm not only that the training protocol results in increased peak moment in ranging corner joints at the greatest biomechanical values, but also in increased cumulative work, as well as in the achieved strength in unit of time. The results show that strength increases through all three segments in both angular velocities tested.

## CONCLUSION

By applying the statistical analysis of the results in the control and experimental groups, we evaluated the training protocol of iso-kinetic exercising and found that it caused the desired positive effects in increasing muscle strength of knee flexors. Additional exercise program on the iso-kinetic machines allows continuous resistance in all ranges of motions, which other exercise equipment (fitness equipment, etc.) do not allow. This feature is important not only to significantly increase muscle strength, but also to increase balancing the relations between muscle extensors and flexors of dynamic knee stabilizers. The

research results confirm the results of previous research on iso-kinetic training, and on that basis we recommend further research on the design of protocols of iso-kinetic exercise for the purpose of characterization of the expediency of iso-kinetic machines to enhance and preserve the strength of knee flexor muscles.

## LITERATURE

1. Aagaard, P, et al (1998) *A New Concept For Isokinetic Hamstring: Quadriceps Muscle Strength Ratio*. The American Journal of Sports Medicine 26:231-237.
2. Brown, LE, et al. (1994): *Effect of velocity on the bilateral deficit during dynamic knee extension flexion exercise in females*. Isokinetics Ex. Sci. 4(4) Biodex #91-231
3. Clarke, R, et al. (1998) *Effect of a 6-week slideboard training program on quadriceps and hamstrings peak torque, vertical jump, and agility*. The American J of Sports Medicine, Vol. 26, No. 2: 254-61, Biodex #93-199
4. Dauty M, et al. (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.
5. Ergun M, et al. (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.
6. Kellis S, et al. (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.
7. Kazazović E, et al. (2007) *Utjecaj trenaznih programa na povećanje max. jačine dinamičkih stabilizatora koljena kod aktivnih sportaša*, New technologies in sports, Sarajevo.
8. Kazazović E., Tabaković M. (2008). *Influence of the maximum strength of dynamic knee stabilizers on the field of movable balance, utjecaj maksimalne jačine dinamičkih stabilizatora koljena na motorički prostor ravnoteže*. 5 International scientific conference on kinesiology, Faculty of Kinesiology. Zagreb. Croatia. Septeber 10-14.
9. Kazazović, E., Hadžikadunić A., Kozić V. (2008) *Effects of additional exercise programme performed with Biodex apparatus at the maximal strength of the dynamic stabilization of knee muscles in active handball players*. Youth sport, 4th International Symposium, Ljubljana.
10. Kazazović, E., Kozić, V., Hadžikadunić, A. (2008), *Differences in dynamic knee stabilizers strength between football and handball players aged 18 to 22*, Međunarodna naučna konferencija, Teorijski, metodološki i metodički aspekti fizičkog vaspitanja, Beograd.
11. Gleeson, N.P., Mercer, T.H. (1996). *The utility of isokinetic dynamometry in the assessment of human muscle function*. Sports Medicine, 21(1), 18-34.
12. Madsen, O.R. (1996). *Torque, total work, power, torque acceleration energy and acceleration time assessed on a dynamometer: reliability of knee and elbow extensor and flexor strength measurements*. European Journal of Applied Physiology, 74, 206- 210.
13. Schlumberger, A, et al. (2006.). *Muscle imbalances – fact or fiction?* Isokinetics & Exercise Science, 1(14), 3-11.
14. Zakas, A. (2006.). *Bilateral isokinetic peak torque of quadriceps and hamstring muscles in professional soccer players with dominance on one or both two sides*. The Journal Of Sports Medicine And Physical Fitness, 46 (1), 28-35.

## EFEKTI PROGRAMA IZOKINETIČKOG VJEŽBANJA NA JAČINU FLEKSORA KOLJENA

Originalni naučni rad

---

### Sažetak

Svrha ovog istraživanja je da ispita maksimalni moment sile, ukupni rad, kao i prosječnu snagu mišića fleksora dinamičkih stabilizatora koljena. Ispitanici koji su sudjelovali u ovom istraživanju su studenti Fakulteta sporta i tjelesnog odgoja u Sarajevu (40 studenata). Procjena promjena nastalih uslijed dodatnog programa vježbanja baziranog na izokinetičkim vježbama (koncentričnim i ekscentričnim) mišića stabilizatora koljena izvršena je na svih 40 ispitanika, podijeljenih na eksperimentalnu i kontrolnu grupu. Maksimalna jačina dinamičkih stabilizatora koljena testirana je na izokinetičkom instrumentariju (aparata Biodex 3) na ugaonim brzinama veličine 60°/s i 180 °/s. Pored redovne nastave na Fakultetu sporta i tjelesnog odgoja eksperimentalna grupa je provodila dodatni trenazni program na aparatu Biodex 3 u trajanju 3 puta sedmični kroz 12 sedmica. Rezultati istraživanja upućuju na to da dodatni program izokinetičkih vježbi na izokinetičkom instrumentariju efektivno poboljšava jačinu mišića fleksora koljena.

**Ključne riječi:** mišići koljena, izokinetički trening, efekti

---

Elvir Kazazović, MS.  
Faculty of Sport and Physical Education,  
Sarajevo university  
71 000 Sarajevo, Bosnia and Herzegovina.  
Tel. +38761 145590 Fax: +38733 634046  
E-mail: kazazovice@yahoo.com