Physiological adaptations of a specific muscle-imbalance reduction training programme in the elite female judokas

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Abstract

Background and Study Aim: Use of isokinetic dynamometers can provide effective tool for both evaluation of strength imbalances and implementation of isokinetic strength training exercises. The aim of this study was to determine the effect of isokinetic training combined with judo techniques to correct imbalances of femoral muscle in elite female judokas.

Material/Methods: Fifteen elite female judokas of the Serbian national team took part in the study. They were exposed to specific training program on isokinetic dynamometer, with individual dosage during the training period of 6 weeks. A specific training program consisted of isokinetic exercises for knee joint, at different angular speeds, which gave the corresponding resistance.

Results: There was a statistically significant improvement in both legs in force flexors (KF-R, KF-L) and the extensors force of the left leg (KE-L) at the level of significance $p<0.01$, whilst the significant enhance in the power of the right leg extensor (KE-R) were found at the level of significance $p<0.05$, in absolute as well as in relative values. Furthermore, flexor-to-extensor torque in initial measurement represented a potential source of injury. After application of the combined training of treatment, this difference was reduced ($p<0.01$) and brought to an acceptable level, respectively.

Conclusions: This study showed that isokinetics could provide useful information regarding strength of particular muscle groups and finding early detection of imbalance between muscle groups in judo sport. Therefore, the authors recommend the inclusion of isokinetic dynamometry as a prevention of injuries and strength diagnostics tool for elite judo athletes.

Key words: isokinetic dynamometer • exercise • judo • muscle-imbalance

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Background

Isokinetic exercise can significantly improve the results in certain sports fields and reduce the incidence of injuries [1,2]. The contemporary competitive judo is highly demanding with respect to physical fitness not only for achieving sport successes but for minimizing the risk of injuries as well [3]. During a high-intensity action in judo bout, the contestants are trying to throw each other on the back or to control the opponent in the ground phase [4–6]. It is well known that the majority of elite judo competitors, over the years of training, develop specific techniques (specialties) that are frequently used in competitions and consequently being

Isokinetic dynamometer – a device that measures: force, moment of force (torque), power and strength of different muscle groups. It provides a useful method for performance testing and rehabilitation methods for the ankle, knee, hip, wrist, elbow and shoulder.

Exercise – is any bodily activity that enhances or maintains physical fitness and overall health and wellness. It is performed for various reasons. These include strengthening muscles and the cardiovascular system, honing athletic skills, weight loss or maintenance and for enjoyment.

Judo – is a modern combat sport created in Japan in 1882 by Dr Kano Jigoro. Its most prominent feature is its competitive element, where the object is to either throw or takedown one's opponent to the ground, immobilize or otherwise subdue one;s opponent with a grappling maneuver, or force an opponent to submit by joint locking or by executing a strangle hold or choke.

Muscle-imbalance – occurs when a muscle, or group of muscles, has to overcompensate and work harder due to other muscles not working hard enough. By working twice as hard to do the same task, one muscle can become bigger and stronger while another becomes smaller and weaker.

transmitted during a training process in which they develop strength imbalance and increasing repetitive mechanisms of injuries [7]. Moreover, strength imbalances have been found one of the strongest injury predictors in high competitive sport [8,9]. Thus, strength imbalance should be treated during year long training process and one of possibilities is to include specific judo exercise which put additional stress to nondominant side. The use of isokinetic devices provides effective tool for both evaluation of strength imbalances and implementation of isokinetic strength training exercises. These testing may be of significant importance for the early detection of muscle unbalance characteristic for some athletes (practicing *Tokui-waza* to one side), which occurred as a result in many years of practicing a judo activity [3]. Moreover, implementation of regular isokinetic training regimes in addition to highlighted exercises of nondominant side during judo training process could have positive impact on strength imbalances.

Therefore, the study aim is to determine the effect of isokinetic training combined with judo techniques to correct imbalances of femoral muscle in elite female judokas.

Material and Methods

Fifteen elite female judokas of the Serbian national team (age 22.86±2.80 years, height 167.46±8.15 cm, body mass 60.80±8.89 kg, training experience 14.00±3.09 years) took part in the study.

Thigh muscle strength was measured under isokinetic conditions using "Easy-Tech" dynamometer in concentric-concentric mode according to standard protocol, with subject in sitting position. Prior to every test the machine was calibrated, ROM was set at 90°, and a warm-up consisted of bicycle run and stretching of quadriceps and hamstring muscles, applied. A more specific warm-up consisted of 3–4 repetitions at the testing speed (60°/s) for both quadriceps (knee extensor) and hamstring (knee flexor) muscles in order to prepare the subject for regular testing. After 2 min the subjects performed 4 repetitions of maximal voluntary contractions (RM) of thigh muscles. The same person conducted all measurements and the same protocol was used for both legs [10,11].

Female judo athletes were exposed to specific training program on isokinetic dynamometer (Easy-tech prima DOC), with individual dosage during the training period of 6 weeks. A specific training program consisted of isokinetic exercises for knee joint, at different angular speeds, which gave the corresponding resistance. Training program on isokinetic apparatus consisted of maximum intensity exercise lasting 1–3 minutes, with a resting period of 1–4 minutes during 45 minutes of training, with a resistance that was gradually increased over the week, with different angular speeds (300–60°/s), from first to sixth week. Training process was performed 3 times a week.

In the first week athletes were practicing (exercising) at speeds of 300–250°/sec. During session they warmed up and trained for regime of isokinetic exercise, and also worked on the knee joint mobility. In the second week subjects trained at speeds of 300–180°/sec., during which they worked on the perservance (endurance) of a given mode, which also develops muscle strength, with less resistance. In the third and fourth week athletes trained at speeds of 250–60°/sec., in which they were still working on endurance, but most of the training was focused on the development of force extension and especially knee flexors. In the fifth and sixth week subjects were trained at speeds of 180–60°/sec., and the emphasis was on the development of force of extensors and knee flexors. At the beginning and at the end of experiment treatment, tests were made from which the data of upper leg force were collected. At the beginning of each session during the six week training period athletes were warmed up in an appropriate manner through stretching exercises on the mat and the isokinetic dynamometer at speeds of 300–270°/sec. During the experiment, athletes had to practice, at technical judo training, the techniques on both sides, while the emphasis was on the weaker side in ratio 60:40%. As part of judo training forced insisting techniques (Ken-ken) was used to improve the power of thigh flexors, where the initial measurements showed the largest imbalance.

Relative peak values of thigh muscle torques were recorded: right and left knee extensors (KE-R and KE-L, respectively), and right and left knee flexors (KF-R and KF-L, respectively). Functional asymmetry was defined as absolute lateral difference (disregarding the sign) expressed as percentage of the muscle torque of dominant side. The flexor-to-extensor ratios were computed and expressed in percentages. The data were subjected to Paired-Samples T Test, with the level of $p \leq 0.05$ being considered significant.

Results

The results of muscle torque measurements for knee flexors and extensors are presented in Table 1, the ratios of flexor-to-extensor torques in Table 2 and absolute percent asymmetry indices in Table 3. Table 1 shows the results and compares the initial and final measurements as well as the difference in measurements. There was a statistically significant improvement in both legs in force flexors (KF-R, KF-L) and the extensors force of

Table 1. Mean values (±SD) of absolute and relative peak muscle torques of the knee joint extensors and flexors.

VARIABLE	Initial		Final	
	M	SD	M	SD
KE-R	172.33	27.82	177.06*	27.77
KE-L	173.46	25.67	178.40**	26.91
KF-R	73.26	18.90	83.93**	15.38
KF-L	68.93	12.98	83.60**	12.23
KE-R/W	2.83	0.25	2.91*	0.24
KE-L/W	2.86	0.26	2.94**	0.24
KF-R/W	1.20	0.27	1.38**	0.19
KF-L/W	1.14	0.18	1.38**	0.18

KE – Knee extensors; KF – Knee flexors; R – Right; L – Left. * Significantly ($p<0.05$) different intial *vs.* final; ** significantly ($p<0.01$) different intial *vs.* final.

Table 2. Mean values (±SD) of flexors-to-extensors ratios (%) for right and left leg.

VARIABLE	Initial		Final	
	M	SD	M	SD
R	42.52	8.58	47.49**	5.00
L	39.69	4.34	47.09**	4.20

* Significantly ($p<0.05$) different intial *vs.* final; ** significantly ($p<0.01$) different intial *vs.* final.

Table 3. Mean values (±SD) of absolute right-left asymmetry of peak muscle torques.

VARIABLE	Initial		Final	
	M	SD	M	SD
KE	6.84	3.76	3.43**	1.87
KF	11.88	9.51	5.36**	5.72

** Significantly ($p<0.01$) different intial *vs.* final.

the left leg (KE-L) at the level of significance $p<0.01$, whilst the significant enhance in the power of the right leg extensor (KE-R) were found at the level of significance $p<0.05$, in absolute as well as in relative values.

The ratios of flexor-to-extensor torques (Table 2) in initial measurement represented a potential source of injury. After application of the combined training of treatment, this difference was reduced ($p<0.01$) and brought to an acceptable level.

Table 3. shows statistically significance decrease in flexor and extensor asymmetry. Significance level was $p<0.01$.

Discussion

Asymmetry indices were computed for given group of athletes, which reflected in absolute right/left differences, i.e. higher of the two values had been attributed to dominance of given leg. The lateral asymmetry in peak muscle torques may be obscured by individual dominance of the right or left leg. For that reason, mean values presented for the right and left legs may not reflect the sport-specific features. Thus, specific judo throwing techniques (*Uchi-mata, Harai-goshi, Osoto-gari* and *Ouchi-gari*) [12] and sport-related development of movement patterns proved safe regarding the risk of marked functional asymmetry. In case of a large number of techniques, a judo contestant bears his/her weight on his "stand-up" leg, while he uses the other leg to throw the opponent to the ground. This specificity is completely understandable, since the *Tokui Waza* technique, "the favorite" or "best" technique, a technique that brings judo practitioners the highest number of technical points, is always practiced from the same position, subjecting the same side of the body to the pressure and re-occurrence of injury [7,13]. Bilateral muscle asymmetry and muscle imbalance regarding the knee have been stated as the etiology of many injuries, especially hamstring strains [7,8,14–18]. The question, whether correction

of any muscle imbalance could reduce the risk of injury, or maybe muscle imbalance causes injury, has not been fully investigated yet.

In addition, assessing muscle balance is considered to be important in terms of prevention of sport injuries and early detection of hamstring/quadriceps misbalance or imbalance between legs. Studies have confirmed that different types of training (e.g. balance training) may correct imbalances of left and right leg as well as the upper knee extensor and flexor muscles [19]. Our research supports the necessity of practicing techniques on both sides (right and left), regardless of the competitive excellence and tactics [20] as well as the benefit of isokinetic training in the prevention and correction of upper thigh misbalances in elite judo athletes.

The most frequently reported strength ratio of the knee muscles to date has been the concentric hamstring-quadriceps (Hcon/Qcon) ratio. Steindler [21] advanced the generalization that absolute knee extension muscle force should exceed knee flexion force by a magnitude of 3:2 (i.e. Hcon/Qcon of 0.66). There seems to be little consensus of a normative value for this conventional H/Q ratio, although 0.6 seemed to have gained some general acceptance. Injury prevention by detection of muscle imbalance should be based on a minimum concentric H/Q ratio of 0.60 at the angular velocity of $60°\cdot s^{-1}$ [22].

Strength deficits between legs or between agonist-antagonist muscle groups have also been reported in sports with asymmetric kinetic patterns like soccer [23,24] and volleyball [25] as well as in sport with symmetric motor patterns like running [26] and cycling [27].

Conclusions

Most of professional judo athletes assess muscle strength primarily using free weights. However, this study showed that isokinetics could provide useful information regarding strength of particular muscle groups and finding early detection of imbalance between muscle groups in judo sport. Therefore, we recommend the inclusion of isokinetic dynamometry as a prevention of injuries and strength diagnostics tool for elite judo athletes and their rehabilitation.

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