MUSCLE STRENGTH ASSESSMENT OF UPPER AND LOWER LIMBS IN ELITE MALE KARATE ATHLETES: COMPARATIVE STUDY BETWEEN DIFFERENT AGE GROUPS

Borislav Obradović[1], Dejan Madić[1], Patrik Drid[1], Milica Bogdanovski[1] and Goran Sporiš[2]

[1]University of Novi Sad, Faculty of Sport and Physical Education, Serbia
[2]University of Zagreb, Faculty of Kinesiology, Croatia

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Abstract
The main aim of this study was to characterize the muscle strength profile the shoulder external and internal rotators and the knee flexors and extensors in elite Serbian male Karate athletes. The second aim was to compare the muscle strength between the hamstrings and quadriceps in male karate athletes of different age groups.The sample was composed of three groups of male karate athletes. First group included seniors (24.1±3.72), the second-juniors (17.6±0.84) and the third group was composed of cadets (15.85±0.69).The following isokinetic parameters were used in the research: Maximal force of right leg extensors (Right_Ext), Maximal force of left leg extensors (Left_Ext), Maximal force of right leg flexors (Right_Flx), Maximal force of left leg flexors (Left_Flx), Maximal force of external rotation of the right arm (Right_Ext_Rot), Maximal force of external rotation of the left arm (Left_Ext_Rot), Maximal force of internal rotation of the right arm (Right_Int_Rot), Maximal force of internal rotation of the left arm (Left_Int_Rot). Based on the discriminant analysis, all variables significantly contribute to the difference between the groups, except maximal force of internal rotation of the right arm. We found that the seniors significantly differ from the cadets in all parameters, and the difference is in favour of seniors ($p \leq 0.05$). Seniors and juniors differ in maximal force of left leg extensors, maximal force of right leg flexors, maximal force of internal rotation of the left arm and maximal force of external rotation of the left arm. Juniors and cadets differ in maximal force of left leg flexors and maximal force of internal rotation of the left arm, the difference is in favour of juniors. To conclude, the lower and upper limbs' isokinetic parameters were significantly higher in the senior compared junior and cadet group. Since only elite competitors were tested, the findings could be of importance for both the selection and training design of karate athletes.

Key words: *isokinetic, testing, selection, karate, difference.*

Introduction

Karate, being one of the most practised individual and martial art worldwide, shall for the first time be included in the Olympic Games, which shall be hosted by the Japanese capital Tokyo in 2020. This sport includes many static positions and dynamic movements and it is characterised by various strikes, both by fists and feet. Karate is divided into kata and kumite. Kata represents a set of forms in pre-established sequences of offensive and defensive techniques and movements, while kumite is a real match or fight between two competitors under strict rules; they are free to move, use the kicks and punches in defensive and offensive manners (Chaabene et al., 2012). In accordance with the development of modern karate, self-improvement is of great importance. The highest level of martial arts is reflected in the fact that the strike is performed at maximum speed and power, but it is stopped at the moment of contact (Mori et al., 2002), so that the opponent does not get hurt (Critchley et al., 1999).In order to properly direct flow of the modern karate development, the influence of science is necessary, both for a better implementation of the training sessions, and thus for the improvement of the results. Diagnostics occupies one of leading positions in planning and programming of training processes in karate. Based on of the competitive activities of athletes, basic model characteristics are obtained, which are necessary for successful training sessions and competitions, but also for the prevention of injuries in karate. Adequate levels of power and its balance between the muscles are essential for the proper functioning and stability of joints. Insufficient presence of power and disrupted balance of power between the muscles can impede the movement and therefore reduce the physical activity of athletes. In order to identify muscle imbalances and prevent possible injuries, the assessment of the muscle function after muscle fatigue is very important. Relation between hamstrings and quadriceps (H/Q ratio) is used as a measure of knee muscles balance. The imbalance between these two muscle groups is associated with greater susceptibility to injury in the knee joint. Isokinetic dynamometers are widely used for studying muscles functions, because they allow dynamic, objective, accurate and reproductive evaluation (Siqueira et al., 2002). The isokinetic diagnostics is very important in preventing injuries and damages to the musculoskeletal system. In cases of athletes when detecting and correcting imbalances of different muscle groups can help prevent injuries, the isokinetic diagnostics is of essential importance. This type of diagnostics can be used for comparing effects of sports injury treatments, but it can be

also used for analysing different methods. Isotonic and isokinetic movements are two types of muscle regimes that are commonly used in sports medicine (e.g. for monitoring elite athletes) and functional rehabilitation (e.g. recovery of muscle strength after knee surgery) (Remaud et al., 2009).

Bilateral asymmetry represents the lack of perfect composition of two limbs (Herzog et al., 1989), i.e. the difference between the two corresponding parts of the body that are located on the opposite side in relation to the medial axis of the body (Jelicoeur, 1963). Impellizerri et al. (2008) used the isokinetic dynamometer for determining the imbalance of power between the hamstrings and quadriceps.

According to them, unilateral and bilateral relations have poor relative reliability and are more suitable for the detection of major changes that are associated with the sports medicine and rehabilitation programmes. Based on the testing conducted by using an isokinetic chair, a number of typical imbalances between antagonistic muscle groups, as well as their specificity for particular sports, have been identified so far (Golik-Perić et al., 2011; Drid et al., 2009).

The main aim of this study was to characterize the muscle strength profile the shoulder external and internal rotators and the knee flexors and extensors in elite Serbian male Karate athletes. The second aim was to compare the muscle strength between the hamstrings and quadriceps in male karate athletes of different age groups.

Methods

Subjects

The sample was composed of three groups of male karate athletes. First group included seniors (24.1±3.72), the second- juniors (17.6±0.84) and the third group was composed of cadets (15.85±0.69). All subjects are active athletes that won medals at national and international competitions.

All measurements were carried out in accordance with ethical rules and each subject participating in the measurements was presented with an explanation of the procedure provided for the research and measurement. In the end, participants signed the consent confirming that they are familiar with the purpose and objectives of measurement, measurement protocol and possible risks of measurement and that they are voluntarily accept the measuring process.

Procedures

For testing the isokinetic muscle strength of the knee flexors and extensors, as well as external and internal rotations of the shoulder joint, the HUMAN NORM isokinetic dynamometer has been used. Before each of tests, the device is calibrated for each of the participantin accordance with the protocol. One person performed both giving instruction to the patients prior to testing and measurement. Range of motion of the tested extremity was 90 degrees. The testing started with the warm up and was followed by a period of rest for 2 minutes before performing maximal contraction. Testing the maximum muscle strength of subjects was carried out at an angular velocity of 60º/sec.

According to Burkett (2000) the best choice in terms of muscle strength and endurance parameters is 60 to 180°/s. Four maximal contractions were performed in a row, both for right and left leg and right and left arm.

The following isokinetic parameters were used in the research: Maximal force of right leg extensors (Right_Ext), Maximal force of left leg extensors (Left_Ext), Maximal force of right leg flexors (Right_Flx), Maximal force of left leg flexors (Left_Flx), Maximal force of external rotation of the right arm (Right_Ext_Rot), Maximal force of external rotation of the left arm (Left_Ext_Rot), Maximal force of internal rotation of the right arm (Right_Int_Rot), Maximal force of internal rotation of the left arm (Left_Int_Rot).

Statistical analysis

The data were processed by using the appropriate statistical methods in the software package IBM SPSS 20.0.For all analysed variables the descriptive statistics was performed (minimum, maximum, mean and standard deviation). Due to the small number of subjects in each group (9-10 participants) the normality of results distribution was analysed using the Shapiro-Wilk test.

Discriminant analysis was used to determine whether there are differences between the groups. T-test was used to determine differences between different categories of elite male karate athletes.

Results

Table 1 presents the mean, standard deviation (SD), minimum and maximum values of the parameters obtained during isokinetic tests of knee extensor and flexor muscles and external and internal shoulder rotator muscles, and also shows statistical significance of Shapiro-Wilk test of normality. If the value of the Shapiro-Wilk test is less than 0.05 (Sig .< 0.05), distribution does not deviate from a normal distribution, and vice versa.

From the results, it can be seen that none of the parameters in all three groups do not differ significantly from the normal distribution. In all parameters seniors have the highest means values in relation to the juniors and cadets.

Based on the discriminant analysis (Table 2), all variables significantly contribute to the difference between the groups, except maximal force of internal rotation of the right arm. In the further processing of the data we analyzed only parameters that significantly contribute to the difference between the groups.

Table 1. Descriptive statistics

Variable	Group	Min	Max	Mean	Std. Deviation	Shapiro-Wilk (Sig.)
Right_Ext	senior	164	275	212.78	34.535	.790
	junior	129	233	182.80	34.473	.583
	cadet	91	194	157.75	32.932	.310
Left_Ext	senior	161	278	215.78	35.598	.978
	junior	130	231	177.70	39.200	.193
	cadet	88	172	147.50	27.140	.061
Right_Flx	senior	110	182	145.67	22.650	.851
	junior	91	141	123.10	14.310	.291
	cadet	69	133	105.63	21.686	.796
Left_Flx	senior	95	201	143.44	34.271	.832
	junior	96	140	122.40	16.105	.071
	cadet	54	132	94.25	23.150	.926
Right_Int_Rot	senior	33	61	44.89	9.675	.532
	junior	24	49	36.70	7.631	.929
	cadet	19	47	31.00	9.681	.770
Left_Int_Rot	senior	33	66	45.67	10.416	.392
	junior	24	52	36.70	7.150	.306
	cadet	20	41	26.63	6.760	.058
Right_Ext_Rot	senior	26	45	35.00	5.937	.913
	junior	22	42	30.30	6.147	.398
	cadet	15	41	27.38	7.726	.961
Left_Ext_Rot	senior	27	47	35.44	6.106	.679
	junior	20	39	28.40	4.926	.329
	cadet	14	34	24.12	5.793	.631

Min-minimum; Max-maximum; SD-standard deviation

Table 2. Discriminant analysis

Variable	Wilks' Lambda	F	df1	df2	Sig.
Right_Ext	.683	5.575	2	24	**.010**
Left_Ext	.593	8.227	2	24	**.002**
Right_Flx	.573	8.934	2	24	**.001**
Left_Flx	.601	7.966	2	24	**.002**
Right_Int_Rot	.698	5.189	2	24	**.013**
Left_Int_Rot	.518	11.182	2	24	**.000**
Right_Ext_Rot	.804	2.931	2	24	.073
Left_Ext_Rot	.572	8.962	2	24	**.001**

Table 3. Difference between age categories

Variable	Group	Mean	t	Sig. (2-tailed)
Right_Ext	senior/junior	212.78/182.80	1.891	.076
	senior/cadet	212.78/157.75	3.351	**.004**
	junior/cadet	182.80/157.75	1.562	.138
Left_Ext	senior/junior	215.78/177.70	2.207	**.041**
	senior/cadet	215.78/147.50	4.401	**.001**
	junior/cadet	177.70/147.50	1.848	.083
Right_Flx	senior/junior	145.67/123.10	2.626	**.018**
	senior/cadet	145.67/105.63	3.711	**.002**
	junior/cadet	123.10/105.63	2.056	.056
Left_Flx	senior/junior	143.44/122.40	1.744	.099
	senior/cadet	143.44/94.25	3.420	**.004**
	junior/cadet	122.40/94.25	3.043	**.008**
Right_Int_Rot	senior/junior	44.89/36.70	2.060	.055
	senior/cadet	44.89/31.00	2.953	**.010**
	junior/cadet	36.70/31.00	1.399	.181
Left_Int_Rot	senior/junior	45.67/36.70	2.208	**.041**
	senior/cadet	45.67/26.63	4.404	**.001**
	junior/cadet	36.70/26.63	3.042	**.008**
Left_Ext_Rot	senior/junior	35.44/28.40	2.781	**.013**
	senior/cadet	35.44/24.12	3.908	**.001**
	junior/cadet	28.40/24.12	1.693	.110

Table 3 shows the isokinetic torque values of knee extensor and flexor muscles and external and internal shoulder rotator muscles, in concentric muscle action of dominant and non-dominant limbs, for the variables that significantly contribute to the difference between groups on the basis of discriminant analysis.From the results it can be seen that the seniors significantly differ from the cadets in all parameters, and the difference is in favour of seniors. Seniors and juniors differ in maximal force of left leg extensors, maximal force of right leg flexors, maximal force of internal rotation of the left arm and maximal force of external rotation of the left arm. Differences in all parameters was also in favour of seniors. Juniors and cadets differ in maximal force of left leg flexors and maximal force of internal rotation of the left arm, the difference is in favour of juniors.

Discussion

The aim of this study was to characterize the muscle strength profile of shoulder and knee and to compare the muscle strength between the different age groups. The isokinetic strength parameters of internal and external shoulder rotation and of knee flexion and extension were significantly higher in the senior compared junior and cadet group. The importance of extensor muscles (quadriceps femoris), as well as the knee joint flexors (hamstrings) and their relative strength for the integrity and stability of the knee joint, which is the most complex joint in the human body, is well known (Dibrezzo et al., 1985). Isokinetic testing gives accurate assessment of the balance of muscle strength (Grygorowicz et al., 2010). The strength of quadriceps and hamstrings is mainly quantified by torque at maximum voluntary isokinetic contractions, while torque relations used for assessing the asymmetry of limbs and hamstring strength compared to the strength of the quadriceps (Willigenburg et al., 2015).The lack of strength in the aforementioned muscle groups can increase the risk of lower limbs injuries

(Willigenburg et al., 2015), but can also help preventing these injuries (Grygorowicz et al., 2010). Differences in terms of the ratio of muscles strength between hamstrings and quadriceps among athletes engaged in different sports may depend on the chosen sport, competition level or both, while in sports with similar lower limbs movements and similar levels of competition any difference between those muscle groups may not arise (Rosene et al., 2001).

Previous results have showed a significant correlation between the H/Q ratio and isokinetic speed in men, as well as a significant increase in the H/R ratio with increasing speed, from the lowest to the highest compared speed (Hewett et al., 2007) .In study of Hewett et al. (1999) isokinetic dynamometer measurements show that male athletes demonstrate significantly greater H peak torque values with increasing maturity.

By regular testing during the season, Golik et al. (2011) found muscle imbalances or lack of strength in 38 athletes (of 196 tested). Bilateral differences between muscle strength in 5% of knee extensors and 8%of the knee flexors, for tested angular velocity of 60º/s were discovered while testing mentioned athletes.

Based on the analysis of previous works, Hewett et al. (2008) concluded that there are significant differences in the relative muscle strength of the quadriceps and hamstrings at increased isokinetic speeds between men and women.

Destombe et al. (2006) concluded that the injuries in karate are fairly common, but are usually minor (inferior). Injuries occur more often during training sessions (63 of 83 injuries) than during the competition (20 of 83 injuries). The head and limbs are the most injuries regions. Long hours of weekly training sessions and higher rankings are associated with an increased risk of injury, suggesting that prevention is crucial.

In the study Birrer & Halbrook (1988), the majority of injuries (47%) included lower limbs, 27% of the upper limbs and 18% of the injuries included the torso. Only 6.4% of injuries involved the head, face and neck. Muscle strength and balance play a key role in targeted acute muscle injuries, while rehabilitation programme emphasizes exercises for strengthening rather based than specific deficits until the normalisation of specific isokinetic parameters (Croisier, 2004).

Results of the study conducted by Aagaard et al. (1998) suggest that the hamstring muscles have the ability to provide significant dynamic joint stability in a fast and strong extension of the knee. Rezaei et al. (2014) in his study compared the characteristics of bilateral strength flexors and extensors of the knee joint in healthy men and women at speeds between 60 and 80°/s. The results showed that torque was higher in men than in women and the H/R ratio was higher in women than in men. Bilateral differences in torque between the dominant and non-dominant leg during eccentric flexors contractions were found and there was no difference in the relation hamstrings/quadriceps.

However, with the increase of speed the H/R ratio increased, too. Zetaruk et al. (2005) studied five different martial arts and came to the conclusion that only in taekwondo more injuries are recorded than in karate.

Most injuries in both of these martial arts include the lower limbs, followed by the upper limbs, head and neck and the least frequent are injuries of the groin and torso. In addition, they found that younger subjects, those under 18 years, are at a much lower risk of injuring compared to adults. Lower risk of less experienced young subject is explained on the basis of lower body weights and less technical skills.

Scattone-Silva et al. (2012) assessed the level of torque development in the muscles of the knee and elbow joints in elite karate athletes in order to recognise the adaptation to regular training session at the martial arts and, in addition, they identified the muscle torque or the asymmetry could predetermine the injury of the aforementioned joints.

Results showed no significant difference between dominant and non-dominant lower limbs in all studied variables during flexion or extension of the knee, at different speeds. Values of the ratio torque/body weight both in the dominant and non-dominant limbs were very similar, as well as muscle recruitment parameters, with differences of less than 10% between the limbs.

They concluded that practising karate on a daily basis does not lead to bilateral asymmetry of the lower limbs which could be associated with an increased risk of injury. Rosene et al. (2001) found no significant differences in terms of body sides or sport, nor the H/Rratio between athletes engaged in different sports.

A statistically significant difference in the strength of the dominant leg in relation to the non-dominant one, at angular velocities of 60 and 180°/s was determined in elite Olympic taekwondo athletes belonging to different weight categories (Hammami et al., 2013).

To some extent the current study is limited by the sample sizes for each group. However, we wanted all subjects to be elite in age groups, in order to have comprehensive conclusions about influence of karate to muscle adaptations after many years of training. Since only elite competitors were tested, the findings could be of importance for both the selection and training design of karate athletes. To conclude, the lower and upper limbs' isokinetic parameters were significantly higher in the senior compared junior and cadet group.

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Correspondence to:
Borislav Obradović
University of Novi Sad,
Faculty of Sport and Physical Education,
Serbia
Tel: +381 21 4852000
E-mail: protokol@uns.ac.rs