Patrik Drid[1], Sergej Ostojić[2], Nebojša Maksimović[1], Jovan Pejčić[1], Radenko Matić[1] and Slavko Obadov[1]

The effects of judo training on
anthropometric characteristics and motor abilities of primary school boys

Key words: **functional coordination, power, skin fold.**
Ključne riječi: **funkcionalna koordinacija, snaga, kožni nabor**

Original scientific paper

Abstract
The aim of this study is to investigate the effects of judo training on anthropometric characteristics and motor abilities of boys, aged 11 to 15 from the Serbian province of Vojvodina. On the sample of 117 school-aged boys who train judo, and 254 boys who do not, anthropometric characteristics and motor abilities have been compared with an independent t-test. Results have clearly shown better performance in motor tests by the judo-trained, as well as differences in subjects in anthropometric characteristics. The effects of judo training on anthropometric characteristics and motor abilities are reflected in changes in circular dimensions with regard to statistically significant differences in speed, strength and coordination in the judo-trained compared with the judo-untrained participants.

Sažetak
Cilj ovog istraživanja je da se ispitaju efekti džudo treninga na antropometrijske karakteristike i motoričke sposobnosti dečaka, uzrasta 11-15 godina iz Srbije, provincija Vojvodina. Na uzorku od 117 učenika koji treniraju džudo, i 254 koji se ne bave ovim sportom, upoređene su antropometrijske karakteristike i motoričke sposobnosti primenom t-testa za nezavisne uzorke. Rezultati istraživanja su jasno pokazali da su džudisti bolje izvodili motoričke testove, kao i postojanje razlika u antropometrijskim karakteristikama. Efekti džudo treninga odražavaju se na antropometrijske karakteristike i motoričke sposobnosti sa promenama u cirkularnim dimezijama sa obzirom na statistički značajne razlike u brzini, snazi, koordinaciji džudista u odnosu na ispitanike koji se ne bave ovim sportom.

Introduction

The following research represents an evaluation of differences in anthropometric characteristics and motor abilities of school-aged children according to the level of their physical activity by application of anthropometric measures and their motor abilities testing. The rationale for this research is the need to analyse and study the effects of sistematically practising judo, and also a possibility to introduce judo into the greatest possible number of schools curricula throughout the Serbian Province of Vojvodina.
Judo is a sport of high intensity, in which a judoka attempts to throw his/her opponent onto his/her back, or to control him/her during the match on the mat. Both cases require excellent physical conditioning (Thomas et al., 1989; Franchini et al., 2005). The contest lasts five minutes of effective combat, interrupted by frequent breaks of up to nine minutes in total. It represents high and intensive effort of anaerobic type (Bompa, 2000), and according to the majority of researchers who dealt with the issue of match structure (Sikorski et al., 1987; Castarlenas and Planas, 1997; Svischev, 2001; Kahabrishvili et al., 2003), it consists of segments of real contest time (10-30 seconds) and pauses (10-15 seconds).
The study of body composition leads to better insights into classic research of changes during growth and development, and begins broader understanding of nutrition differences, the role of physical activity and factors that influence development (Godina et al., 2007). As it is almost impossible to influence bone size by training, physical excercise is determined according to optimal muscle volume and subcutaneous fatty tissue associated with judo.

[1] *Faculty of Sport and Physical Education, University of Novi Sad, Serbia*
[2] *Faculty of Sports and Tourism, PA University of Novi Sad, Serbia*

Previous research (Drid et al., 2006; Obadov et al., 2006; Al-Hazzaa, 2007) confirmed statistically significant differences between athletes and sedentary people concerning the volume of subcutaneous fatty tissue and percentage of muscle volume.
Motor abilities greatly influence success in a judo contest. For this reason, care needs to be taken of the development of these abilities when first stepping on the judo tatami (Maksimovic, 1998). During many years of training, more requirements for the development of these abilities appear, but it has to be taken into account that characteristics of motor abilities are not just the consequences of genetic predispoditions and social environment factors, but also well-timed, methodically determined training regime for their development. In accordance with regulations of long-time planning and programming, the relation of some programs of sport preparation varies in certain phases (Matvejev, 2000; Platonov, 1997).

Methods

Subjects

The research was conducted on the total of 371 primary school children, aged 11 to 15, from all over the province. The experimental group consisted of 117 boys who practised judo twice a week for a period of 24 months, whereas the other 254 children did not have any kind of judo training during the study. Both groups kept attending their regular physical education classes at school during this 24-month period. The control group was also devided into four subgroups for analyses, based on the subjects' ages (11-12, 12-13, 13-14, 14-15). All children and their parents were fully informed about the nature and purpose of the study, after which they gave a consent for their participation. They also had the opportunity to inform the investigators of relevant health problems.

Experimental protocols and measurements

An evaluation of morphological characteristics of subjects, based on the morphological model constructed by Bala (1981), was carried out by means of anthropometric measures according to the International Biological Programme (Lohman, Roche, & Martorell, 1988). The sample consisted of the following measures:

- evaluating body dimensionality: 1) body height
- evaluating body voluminosity and subcutaneous fat: 2) body weight, 3) chest girth, 4) upper-arm girth, 5) forearm girth, 6) abdominal skinfold, 7) subscapular skinfold, and 8) triceps skinfold.

The battery of eight motor tests used in this research estimates the effectiveness of the following functional mechanisms: movement structuring, tonus and synergetic regulation, regulation of excitation intensity and regulation of excitation duration (Gredelj, Metikos, Hosek, & Momirovic, 1975; Kurelic, Momirovic, Stojanovic, Sturm, Radojevic, & Viskic-Stalec, 1975). Motor abilities of boys and girls were estimated by the following motor test-battery:

- functional coordination: 1) *Obstacle course backwards*, *2) Slalom with 3 balls;*
- frequency of simple movements: 3) *Arm plate tapping*;
- flexibility: 4) *Forward bend*;
- power (explosive strength): 5) *Standing broad jump*;
- muscular endurance (isometric strength): 6) *Bent-arm hang*;
- muscular endurance (isotonic strength): 7) *Crossed-arm sit-ups*.
- speed of running: 8) *20-m dash.*

A short description of the motor tests follows. Every child was given an opportunity to rehearse the test before recording the results. This way more adequate and reliable results were obtained.

Obstacle course backwards: The subject walks backwards on all fours the distance of 10 m, climbs the top of Swedish bench and goes through the frame of the bench. Time is measured in sec.

Slalom with 3 balls: On command "GO" the subject rolls three balls between cones at the distance of 10 m. After having passed the last of five cones, the subject rounds it and continues rolling all three balls toward the start line. Time is measured in sec.

Arm plate tapping: The subject taps alternately two plates on a tapping board with his dominant hand, the other hand being held between plates, for 15 s. The number of double taps is recorded.

Forward bend: The subject sits on the floor in straddle position leaning against the wall, and reaches forward along a straight-angle ruler as far as possible. The reach (in cm) is recorded.

Standing broad jump: The subject jumps with both feet from the reversed side of Reuter's bounce board onto a carpet with scale. The jumping distance (in cm) is recorded.

Bent-arm hang: The subject grips the bar, fingers on top and thumb underneath, pulls up (chin above the bar) and holds the position as long as possible without resting the chin on the bar. Time is measured in sec.

Sit-ups with crossed arms: The subject lies on the back, knees bent, arms crossed on the chest, and performs sit-ups, feet being held fast by an assistant. The number of correctly executed sit-ups in 60 s is recorded.

20-m dash: On command "GO" the subject runs 20-m distance at highest speed possible. The subjects run in pairs. Time is measured in sec.

Consequently, these tests were the manifestation of hypothetical functional mechanism of young people, which means that they could be virtually taken as primary latent motor dimensions. This approach was chosen to decrease the sample of motor tests, due to the significant organizing and motivational problems which exist in testing procedures with school children.

Data analysis methods

During data analysis, basic descriptive statistic measures were calculated for each group separately, while the differences between groups were determined by application of independent t-test and they are presented graphically. Differences were considered significant at $p<0.05$.

Results

Table 1 shows the anthropometric data for Group A (with judo training) and Group B (without judo training) classified by the participants' age.

Analysing the effects of the training process on anthropometric characteristics of judo-trained children, it can be seen that at the age of 11-12 they are not significantly important. The observed significant differences in anthropometric status during this period concerning body height and weight, as well as abdominal skin fold and upper-arm skin fold, are in favour of the judo-untrained children. We can regard this period insufficient for transformation effects of judo training on the measured anthropometric parameters to occur. However, in the next age group (12-13), one can notice that there is significantly less subcutaneous fat tissue of the upper-arm in Group A compared to Group B. The same has been observed for the age of 14-15. Significant transformations achieved by the effects of judo training have been noticed for circular dimensions, where the girths of stretched upper-arm, forearm and chest for Group A were significantly higher than Group B.

Concerning the motor abilities of the judo-trained vs. judo-untrained children, it can be noticed that during some motor tests for assessment of repetitive strength (sit-ups) and coordination (obstacle course backwards running), statistically significant differencies were noticed for ages 11-15. It is interesting that in the second test of coordination (slalom with 3 balls), there were no differences, ie. there was an advantage for the judo-untrained at the age of 13-14. In the speed assessment (20 m run), the judo-trained group showed better results at the age of 11-12 and 13-14. This statistically significant advantage concerning the speed test is accompanied by a better explosive strength in the judo-trained children at the age of 11-12 as well as isometric strength at the age of 12-14. Concerning motion frequency, except for the advantage of the judo-untrained at the age of 13-14, there were no statistically significant between-group differences for the other ages.

Discussion

During the body growth and development, body segments follow a different curve reaching their maximum at different times. For these reasons, the morphological structure of the body, which is based on mutual interactions of all anthropological measures in different phases of development, can be different. In other words, some morphological characteristics can, at different times, participate with different participation coefficients concerning particular morphological structure of the body.

The differences concerning morphological characteristics of both sexes of the judo-trained children cause diversification with regard to the same type of training (Sterkovicz, 1998). Somatic typisation of the judo-trained shows the dominance of the en-

Table 1.
Descriptive statistics of anthropometric characteristics for children with and without judo-training

	Group A		Group B			
	X	SD	X	SD	t	p
Age 11-12	**N=25**		**N=67**			
Body height (cm)	146.79	5.72	152.28	8.09	-3.11	**0.00**
Body weight (kg)	39.53	7.71	44.07	9.90	-2.06	**0.04**
Chest girth (cm)	71.68	5.37	72.42	7.32	-0.46	0.64
Upper-arm girth (cm)	21.70	2.19	21.90	3.00	-0.31	0.75
Forearm girth (cm)	20.28	1.76	20.37	2.02	-0.19	0.84
Abdominal fold (mm)	109.68	81.93	157.82	97.62	-2.19	**0.03**
Subscapular fold (mm)	74.80	36.35	102.33	66.44	-1.96	0.05
Upper-arm fold (mm)	93.92	34.39	139.55	67.69	-3.21	**0.00**
Age 12-13	**N=25**		**N=61**			
Body height (cm)	154.17	8.77	157.99	8.56	-1.86	0.06
Body weight (kg)	46.54	11.98	49.81	11.64	-1.77	0.24
Chest girth (cm)	75.34	7.40	73.96	9.93	0.62	0.53
Upper-arm girth (cm)	22.97	3.48	22.57	3.26	0.50	0.61
Forearm girth (cm)	21.30	2.55	21.25	2.42	0.08	0.93
Abdominal fold (mm)	129.92	88.85	159.90	92.43	-1.38	0.17
Subscapular fold (mm)	81.12	45.11	100.20	63.13	-1.37	0.17
Upper-arm fold (mm)	96.48	41.44	126.95	57.24	-2.41	**0.01**
Age 13-14	**N=35**		**N=66**			
Body height (cm)	163.31	9.60	162.32	9.30	0.50	0.61
Body weight (kg)	55.75	13.80	51.66	10.02	1.70	0.09
Chest girth (cm)	80.68	8.79	76.61	7.00	2.53	**0.01**
Upper-arm girth (cm)	24.30	3.83	22.75	3.17	2.16	**0.03**
Forearm girth (cm)	22.66	2.90	21.30	2.10	2.69	**0.00**
Abdominal fold (mm)	143.26	103.94	144.21	93.54	-0.04	0.96
Subscapular fold (mm)	95.14	60.56	98.85	68.74	-0.26	0.78
Upper-arm fold (mm)	104.23	47.63	118.88	65.61	-1.16	0.24
Age 14-15	**N=32**		**N=60**			
Body height (cm)	169.98	8.51	173.66	8.62	-1.95	0.05
Body weight (kg)	61.99	10.60	61.22	12.57	0.29	0.76
Chest girth (cm)	86.13	7.07	81.56	7.07	2.95	**0.00**
Upper-arm girth (cm)	26.01	2.71	23.95	3.13	3.14	**0.00**
Forearm girth (cm)	24.18	2.10	22.94	2.05	2.74	**0.00**
Abdominal fold (mm)	123.37	71.98	126.80	67.17	-0.22	0.82
Subscapular fold (mm)	80.50	34.39	91.90	54.81	-1.06	0.28
Upper-arm fold (mm)	78.12	20.59	104.13	50.85	-2.76	**0.00**

domorph and mesomorph components with reduced values of the ectomorph component, which was almost the same for both sexes. Importantly, the mesomorph component prevails in lighter children, while the heavier ones show higher values of the endomorph model of the body build (Claessens, 1984). It is also assumed that people with endomesomorph body build achieve better results concerning strength tests. The research presented here demonstrates that a specific judo-training programme may indeed influence skeleton size, showing important positive transformations except for the youngest age.

It is also evident that the judo-trained children of school age of 13-15 had significantly bigger upper-arm girth, forearm girth and chest girth. This can certainly be linked to better results in strength tests because bigger girths of these body segments indicate greater muscle cross sections.

Konsidering the complexity of technical elements of judo, their equal performance is not possible in all weight and sex categories. This is also supported by biomechanics studies which show that the portion in total muscle volume and strength of females was 68% compared to males (Obuchowicz-Fidelus et al., 1985). Successful application of techniques in judo is connected with specific body build of judokas as well as their muscle strength, which has been shown to be lower by 10% for elite competitors from Serbia compared to highly ranked fighters (Drapsin et al., 2007).

Systematic transformation of strength dimensions should start when both active and passive parts of the motion system of young children is strong enough. This can be achieved by training operators for global development of strength of the locomotor system, and especially by the training of speed, coordination, aero-

Table 2.
Descriptive statistics of motor abilities tests

	Group A		Group B			
	X	SD	X	SD	t	p
Age 11-12		N=25		N=67		
20-m dash (s)	4.06	0.26	4.30	0.42	-2.71	**0.00**
Obstacle course backwards (s)	11.53	3.19	16.38	4.34	-5.08	**0.00**
Slalom with 3 balls (s)	37.12	7.71	36.92	6.95	0.11	0.90
Arm plate tapping (freq.)	27.48	4.13	27.30	4.26	0.18	0.85
Forward bend (cm)	46.40	12.02	42.97	8.03	1.57	0.11
Standing broad jump (cm)	179.20	12.81	166.79	22.52	2.59	**0.01**
Bent arm hang (s)	39.47	22.86	29.88	21.25	1.88	0.06
Crossed-arm sit-ups (freq.)	47.24	7.92	37.17	7.94	5.40	**0.00**
Age 12-13			***N=25***	***N=61***		
20-m dash (s)	4.00	0.44	4.13	0.34	-1.40	0.16
Obstacle course backwards (s)	35.92	4.42	15.73	3.73	-3.57	**0.00**
Slalom with 3 balls (s)	41.96	7.46	34.49	5.95	0.93	0.35
Arm plate tapping (freq.)	43.38	5.16	28.70	4.95	0.11	0.91
Forward bend (cm)	4.00	9.15	42.95	9.54	-0.44	0.66
Standing broad jump (cm)	35.92	24.53	172.69	24.31	1.56	0.12
Bent arm hang (s)	41.96	24.77	29.88	23.13	2.40	**0.01**
Crossed-arm sit-ups (freq.)	43.38	11.25	39.41	7.15	2.99	**0.00**
Age 13-14			***N=35***	***N=66***		
20-m dash (s)	3.93	0.30	4.08	0.34	-2.12	**0.03**
Obstacle course backwards (s)	11.74	2.49	15.13	5.72	-3.32	**0.00**
Slalom with 3 balls (s)	37.15	9.88	32.22	5.54	3.21	**0.00**
Arm plate tapping (freq.)	28.43	3.69	30.23	4.40	-2.05	**0.04**
Forward bend (cm)	47.09	9.05	45.08	10.86	0.93	0.35
Standing broad jump (cm)	189.80	23.36	181.61	23.87	1.65	0.10
Bent arm hang (s)	53.93	34.00	33.44	19.89	3.82	**0.00**
Crossed-arm sit-ups (freq.)	47.40	7.75	41.74	6.99	3.72	**0.00**
Age 14-15			***N=32***	***N=60***		
20-m dash (s)	3.68	0.26	3.77	0.29	-1.42	0.15
Obstacle course backwards (s)	11.06	1.96	13.51	2.57	-4.66	**0.00**
Slalom with 3 balls (s)	33.68	5.60	31.48	7.02	1.52	0.13
Arm plate tapping (freq.)	32.63	4.59	32.22	4.50	0.41	0.68
Forward bend (cm)	53.25	10.34	49.53	8.65	1.83	0.07
Standing broad jump (cm)	210.38	21.81	206.97	23.85	0.67	0.50
Bent arm hang (s)	47.20	19.80	51.98	24.28	0.95	0.34
Crossed-arm sit-ups (freq.)	48.56	9.64	44.72	6.23	2.29	**0.02**

bic capacity and flexibility (Milanovic, 1997). More intensive strength training of children should begin after the puberty, provided that strength-training includes changeable loads (eg., own weight or opponent's resistance), while avoiding long static loads. Unlike the active load, static load has bad effects on the blood supply of the loaded structure. It is for this reason that dynamic exercises of strength should be given preference (Jonath and Krempel, 1981; Weineck, 1988).

This study showed that the judo-trained children had better results in repetitive strength (sit-ups), with statistically significant differences observed across all ages.

Special attention should be given to speed development because speed of grown-up judokas is greatly influenced by the age at which its systematic development was started (Obadov, Drid, Nurkic, 2006). Speed should be developed differentially. Exercises aimed at speed development of young judokas should begin at the age of 6-10, motion frequency at the age of 8-13, and training of explosive strength should be implemented at the age of early adolescence. Implementing specific exercises for speed development will give instant effects but will later limit its mature development (Zeljaskov, 2002).

In the speed assessment (20 m run), the judo-trained group showed better performance vs. the untrained concerning speed abilities at the ages of 11-12 and 13-14. This statistically significant advantage in speed is also accompanied by better explosive strength of judokas at the age of 11-12, as well as static strength at the age of 12-14.

The advantage of the judo-trained vs. judo-untrained in coordination, determined by the obstacle course backwards test, can be explained as a consequence of an ongoing acquisition of specific judo techniques for the development of motion coordination. In the second coordination test (slalom with 3 balls), these differences were not present (except for the age of 13-14 where the judo-untrained were better).

Conclusion

The outcomes of this study provide further evidence for the existence of differences in motor abilities and anthropometric characteristics between school-aged boys who underwent a specific, 2-year judo training programme, compared to those who were not judo-trained.

The development of strength, coordination, speed, as well as an increase in circular dimensions, likely achieved by the application of a training process in judo, impose an initiative to implement certain types and principles of judo training into daily physical education classes in schools.

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Correspodence to:
Patrik Drid
Faculty of Sport and Physical Education, University of Novi Sad
Lovćenska 16, 21 000 Novi Sad, Serbia
Phone: +381 21 450 188
E-mail: patrik@eunet.rs