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Fitness Profile of Elite Croatian Female Taekwondo Athletes

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A B S T R A C T

The aim of the study was to assess fitness profile of elite Croatian female taekwondo athletes and to determine which physical, physiological and motor characteristics differentiate mostly the successful from the less successful fighters. Thirteen national taekwondo champions were divided into two groups according to their senior international competitive achievements. Physiological characteristics, including maximal oxygen uptake (VO_2max), were assessed during a continuous progressive treadmill test. The measured motor abilities included explosive and elastic leg strength, maximal strength, muscular endurance, anaerobic alactic power, agility and flexibility. Differences between the successful and less successful athletes were determined using independent t-test. Even though the differences were not statistically significant, the successful athletes had somewhat less fat (2.3%) and were taller by 5.8 cm. The successful athletes achieved significantly higher maximum running speed (15.8 ± 0.5 versus 14.9 ± 0.7 km h^{-1}; $p<0.05$), their ventilatory anaerobic threshold was significantly higher (41.4 ± 4.1 versus 37.6 ± 2.0 ml kg^{-1} min^{-1}; $p<0.05$) at a significantly lower heart rate (166.8 ± 6.8 versus 171.0 ± 8.2 beats min^{-1}; $p<0.05$) than in the less successful athletes. Significant differences were also found in three tests of explosive power ($p<0.05$), anaerobic alactic power ($p<0.01$), and lateral agility ($p<0.05$). The performance of taekwondo female athletes primarily depends on the anaerobic alactic power, explosive power expressed in the stretch-shortening cycle movements, agility and aerobic power.

Key words: *fitness, taekwondo, women, physiology*

Introduction

Taekwondo is a relatively young sport discipline, which has its roots in an old Korean martial art. Significant development of taekwondo as a combat sport started with the foundation of the World Taekwondo Federation (WTF) in 1973. At present, this Korean martial art exists in two forms under the control of two organizing bodies, the World Taekwondo Federation, which accentuates sports competition and performance, and the International Taekwondo Federation (ITF), which advocates for a more traditional form of taekwondo[1]. The traditional (ITF) form of taekwondo includes fights with modified rules, breaking brick and execution of forms. The interest of sports science is mainly focused on the WTF taekwondo practice.

Taekwondo is characterized by specific fast, high and spinning kicks. Movement structures of the sport are considered to be highly demanding for most muscle groups of athletes[2]. The youngest member of the family of the Olympic sports, it has not been substantially studied yet. So, relatively little is known about its functional and energy demands[1,3], as well as about desirable morphological, physiological and motor abilities of taekwondo athletes, particularly female ones. Most previous studies dealt with injuries in taekwondo[4–6].

The authors consider it is generally necessary to determine both the basic and specific fitness profiles of athletes for the sake of selection of athletes for a particular sport or discipline and evaluation of training process. In selection of athletes for a particular sport or discipline, the focus should be on those traits and abilities which have the most significant influence on sport performance, and on those which are predominantly under prevailing influence of genetic factors. In evaluation of training process the fitness profile parameters enable monitoring of trainable abilities (i.e. abilities sensitive to the environmental influence, physical activity in par-

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ticular, that is training programme) that have major impact on sport performance.

So, the definition of the success-related fitness profile structure in taekwondo may be valuable both scientifically and practically.

The aim of the study was to determine fitness profile of Croatian elite female taekwondo athletes and to find which physical, physiological and motor characteristics differentiate mostly the successful from the less successful fighters. Since taekwondo performance is an intermittent interval activity characterized by intervals of the maximal (high-speed) exertion alternating with periods of low intensity performance[1], we hypothesized that explosive power and anaerobic performance might be relevant to successful performance in taekwondo.

Materials and Methods

Subjects

The sample consisted of 13 female taekwondo athletes, members of the Croatian national team. They were divided into two groups (A and B group) according to their senior competitive results achieved either at the European or World championships, or at the Olympic games. A group consisted of six athletes competing in the weight-categories from 51 kg to 72 kg, who had already won one or more medals at the mentioned competitions in the last five years. So it can be stated that the group A has features of top-quality female taekwondo competitors. Seven female athletes in the weight categories from 48 kg to 72 kg in the group B have not yet won a senior medal at the mentioned competitions. Training experience of all the participants ranged from 7 to 10 years. They trained 2 hours per day 5 times a week. Besides the taekwondo training, all athletes have been engaged in supplemental strength and conditioning training for years during both preparatory and competitive period (minimum 2 hours per week). The testing was conducted at the beginning of the preparation cycle (that is at the end of the transition period) for the 2002 European Championship in Turkey.

Testing procedures

A three-day testing was conducted between 10 a.m. and 13 a.m. The first testing session (1st day) included anthropometric measurements, followed by jumping tests, an agility test and two maximal strength tests. The second testing session (2nd day) included testing of anaerobic power and maximal oxygen uptake. The third testing session (3rd day) included testing of muscular endurance. Rests between each test were about 5 minutes. The testing procedure on each day were preceded by a 15-minute warm-up which included 5-minute indoor run at the self-selected pace, calisthenics and execution of 10 squats, 10 heel raises, 10 sit-ups and 10 back extensions. The warm-up ended with a 2-minute static active stretching (about 15 sec. for every major muscle group). Participants were instructed to avoid any strenuous physical activity during the experiment and to maintain their usual dietary habits.

Anthropometric measurements

Body mass, body height and four skinfolds (subscapular, suprailiac, triceps and biceps) were measured using the Harpenden caliper. The percentage of body fat was estimated according to the method of Durnin and Rahaman[7]. Lean body mass was calculated by subtracting the estimated body fat from the total body mass.

Physiological testing

Maximal oxygen uptake (VO_{2max}) was determined by a continuous progressive treadmill test. The treadmill test (Techno-Gym, Runrace 9600) began with three minutes of walking at 3 km/h, and then speed was being increased by 1 km/h every minute until voluntary exhaustion. Inclination was constant at 1.5°.

Expired air was collected and analyzed using the COSMED Quark b^2 (Italy) breath-by-breath gas exchange system. Heart rate was monitored by means of the short-range radio telemetry system (Polar, Finland). These cardio-respiratory values were calculated automatically and were printed every 30 seconds. The decisive criterion for the maximum oxygen uptake assessment (VO_2max) was the moment of achieving plateau in VO_2. The highest values were calculated as arithmetic means of two consecutive highest 30-second values.

Ventilatory anaerobic threshold (T_{vent}) was determined non-invasively from the gas exchange parameters. The systematic increase in ventilatory equivalent for O_2 (VE/VEO_2) without the increase in the ventilatory equivalent for CO_2 ($VE/VECO_2$) was used as a marker of the ventilatory anaerobic threshold[8,9].

Motor abilities

Explosive power of the leg extensor muscles was determined by means of three vertical jumping tests: squat jump (SJ), counter-movement jump (CMJ) and counter-movement jump with the arm swing (CMJA)[10]. Jumping height (the height of the body gravity center elevation) was calculated from the flight time, which was measured by means of the digital timer and contact mat (Ergo-Jump, Bosco System, Italy).

Besides the vertical jump tests, a 20-meter run from the crouch start (20 m sprint), measured with the system of infrared photocells was also used to estimate explosive power. All the explosive power tests were performed three times and an average value of each test score was used in statistical analysis. Rests between each trial lasted 2 minutes.

Elastic reactive strength was determined by means of five consecutive vertical jumps, performed on the contact mat with the knees slightly bent, also known as repetitive jumps (RJ5)[10]. Test was performed three times and average value was used in analysis. Rests between each trial lasted 3 min.

Anaerobic alactic power was determined with a 15-second vertical jumping test (15 sec)[11] with demonstrated reliability[11].

The maximal strength testing consisted of a 1RM bench press and of back squats[12] (back squat – thighs parallel to the floor) performed with the standard Olympic style bar and weights (Ligo, Czech Republic). Two experienced spotters assisted during the maximal strength testing in performance of back squat and bench press. The maximal strength results are expressed in both the absolute and relative (score/body weight) values. All the athletes had participated in the supervised resistance training regularly for at least three years, so they were qualified for execution of many resistance exercises, including bench press and back squat. Since both the proper exercise performance technique and training experience are important in injury prevention[13], injury potential during the maximal strength testing was reduced to the minimum. Before testing the 1RM squat and bench press, a number of warm-up trials were prescribed to the participants as follows: 30% (8 repetitions), 50% (5–6 repetitions), 75% (3 repetitions), and 90% (1 repetition) of an estimated 1RM. Since participants had sufficient experience in training with free weights, they were acquainted with their 1RM values. After 90% of 1RM, loads were increased using small plates (5 kg, 2.5 kg and 1.25 kg) until the 1RM was reached. Adequate rest was allowed between trials (around 3 minutes). Besides warm-up trials, the process of determining the 1RM generally required no more than 4–5 lifts.

Muscular endurance was determined using the maximal number of push-ups in 60 seconds[14] and maximal number of sit-ups in 60 seconds[15]. Flexibility was assessed with the sit-and-reach test[12].

Agility was assessed with the side step test[16], which will be in short described here. Two one-meter long parallel lines, four meters apart, are marked on the floor of a gymnasium. An athlete starts with both feet together near the outer edge of one of the lines. On the timekeeper's sign, a subject performs shuffle steps to the other line without crossing his/her legs. When the athlete touches the other line with his/her outer leg, he/she stops and returns the same way back. The test is completed when the starting line is crossed for the third time (six lateral shuffle crossings of the four-meter distance altogether). Three trials were performed and average value was used in statistical analysis.

Statistical analysis

All statistical analyses were calculated by the SPSS statistical package. The results are reported as means and standard deviations (SD). Differences between two groups were reported as mean difference ± 95% confidence intervals ($mean_{diff}$ ± 95% CI). The intra-class correlation coefficient[17] (ICC) was used to determine reliability of tests used to estimate explosive power, elastic strength, flexibility and agility. Student's t-test for independent samples was used to determine the differences in fitness parameters between the two groups. The $p<0.05$ was considered as statistically significant.

Results

Characteristics of the Croatian female taekwondo athletes in age, body mass, height and body composition are presented in Table 1. There were no significant differences in physical characteristics between A and B groups. Athletes in both groups were similar in their mean age, body mass and percentage of fat. Taekwondo fighters in the A group have in general somewhat less body fat (2.3% ± 3.2%; $mean_{diff}$ ± 95% CI) and more lean body mass (3.5 kg ± 7.6 kg; $mean_{diff}$ ± 95% CI). It is also noticeable that the members of A group are on average 5.8 cm ± 7.3 cm ($mean_{diff}$ ± 95% CI) taller than the members of B group.

Physiological characteristics of the participants are presented in Table 2. The two groups differed significantly ($p<0.05$) in the maximum running speed during the treadmill test, in ventilatory anaerobic threshold (T_{vent}) and in the heart rate at T_{vent}. The athletes in A group achieved significantly higher maximum of running speed and had significantly higher T_{vent} at lower heart rates. The group A had also higher absolute and relative VO_{2max} values, but these differences were not statistically significant.

Table 3 shows the differences in motor abilities between the two groups of female taekwondo athletes and the ICC reliability scores for the explosive power tests, elastic strength test and agility test. The ICC values for

TABLE 1
COMPARISON OF PHYSICAL CHARACTERISTICS OF THE CROATIAN ELITE FEMALE TAEKWONDO ATHLETES WITH SOME PREVIOUSLY REPORTED VALUES FOR FEMALE TAEKWONDO ATHLETES FROM OTHER COUNTRIES (MEAN ± SD)

Variable	All	A group	B group	$mean_{diff}$ ± 95% CI	Heller et al.[1]	Rivera et al.[18]
No. of athletes	13	6	7	–	12	9
Age (years)	21.5±4.1	21.7±4.3	21.3±4.2	0.4±5.3	18.5±2.6	18.1±3.4
Body mass (kg)	60.1±9.0	62.3±8.1	59.8±10.1	2.5±7.9	62.3±7.4	58.6±11.2
Body height (cm)	168.0±6.6	171.1±5.4	165.3±6.6	5.8±7.3	168.0±5.0	163.7±6.9
Body fat (%)	16.5±2.7	15.3±2.0	17.6±2.9	2.3±3.2	15.4±5.1	18.3±5.6
Lean body mass (kg)	49.9±5.8	51.8±5.7	48.3±5.9	3.5±7.6	52.4±4.2	–

TABLE 2
PHYSIOLOGICAL CHARACTERISTICS OF THE CROATIAN ELITE FEMALE TAEKWONDO ATHLETES (MEAN ± SD)

Variable	All	A group	B group	$mean_{diff}$ ± 95% CI
VO_2max (l min^{-1})	2.9±0.5	3.1±0.5	2.8±0.4	0.3±0.5
VO_2max (ml $kg^{-1}\cdot min^{-1}$)	48.3±2.8	49.6±3.3	47.2±2.1	1.9±3.3
Maximum speed (km h^{-1})	15.4±0.8	15.8±0.5	14.9±0.7*	0.9±0.7
T_{vent} (ml kg min^{-1})	39.4±3.5	41.4±4.1	37.6±2.0*	3.8±3.4
T_{vent} (%VO_2max)	81.4±3.9	83.4±4.5	79.4±3.2*	4.0±3.4
Heart rate at T_{vent} (beats min^{-1})	169.1±9.0	166.8±6.8	171.0±8.2*	–4.2±3.8
Running speed at T_{vent} (km h^{-1})	10.6±0.8	11.0±0.6	10.2±0.8	0.8±0.9

* Significant difference between the two group (A and B) of athletes; $p<0.05$

TABLE 3
MOTOR ABILITIES OF THE CROATIAN ELITE FEMALE TAEKWONDO ATHLETES (MEAN ± SD)

Variable	All	A group	B group	$mean_{diff}$ ± 95% CI	ICC
SJ (cm)	28.6±2.8	29.8±2.9	27.7±2.4	2.1±3.3	0.96
CMJ (cm)	30.6±3.4	32.8±3.9	28.7±1.9*	4.1±4.0	0.98
CMJA (cm)	34.9±3.0	36.4±3.5	33.2±2.3*	3.2±3.2	0.97
RJ5 (cm)	30.3±2.8	31.7±1.9	29.1±3.5	2.6±3.0	0.94
15 sec jumps ($W\cdot kg^{-1}$)	24.4±3.4	27.0±2.6	22.1±2.1*	4.9±2.8	–
20-meter sprint (sec)	3.7±0.2	3.6±0.2	3.81±0.1*	–0.2±0.2	0.98
Push-ups (number in 60 sec)	24.4±7.8	25.8±8.5	23.1±7.7	2.7±9.9	–
Sit-ups (number in 60 sec)	55.2±6.1	58.7±7.0	52.2±3.5	6.5±6.7	–
Back squat (kg)	79.0±18.8	89.1±17.6	72.1±15.2	17.0±20.1	–
Back squat $_{relative}$ (kg bw^{-1})	1.3±0.2	1.43±0.2	1.2±0.2	0.2±0.3	–
Bench press (kg)	51.2±11.0	55.7±11.6	48.5±8.2	7.2±16.6	–
Bench press $_{relative}$ (kg bw^{-1})	0.9±0.1	0.9±0.1	0.8±0.1	0.1±0.6	–
Sit-and-reach (cm)	55.8±4.8	54.8±4.5	56.6±5.2	–1.8±5.7	0.96
Side steps (sec)	8.0±0.3	7.8±0.3	8.21±0.2*	–0.4±0.3	0.93

* Significant difference between the two group (A and B) of athletes
ICC – Intra-class correlation calculated for the explosive power tests, elastic strength test, flexibility, and agility test

the selected motor tests were very high, and varied between 0.93 and 0.98.

In all the measured motor abilities, except in flexibility, the A group scored better. The following motor variables significantly differentiated between the two groups: counter-movement jump ($p<0.05$), counter-movement jump with the arm swing ($p<0.05$) and 20 m sprint ($p<0.05$), then side steps ($p<0.05$), and 15 s jumping ($p<0.01$).

Discussion

As previously mentioned, the differences in physical characteristics between the two groups of female athletes were not statistically significant. However, it must be emphasized here that the A group members were 5.8 cm taller than the members of B group. The athletes in A group were also taller than the elite Puerto Rican[18] or Czech[1] female taekwondo athletes. Since taekwondo is a combat sport in which leg techniques are predominant, longer lower extremities may be advantageous for better performance. The results reported by Kuleš[19], obtained on the elite karate athletes, confirm this hypothesis. The magnitude of the difference may be important, but more studies with a greater number of participants are needed to verify that. The Croatian elite female taekwondo athletes (especially A group) had lower average body fat percentage than female physical education students[20,21], majority of female athletes from various sports[22,23], or female taekwondo athletes[18]. Low body fat percentage in female taekwondo athletes was also reported by Heller[1] and associates (Table 1), although they used the different method (ten skinfold measurements)[24] in the percentage of fat estimation. Mean lean body mass of the Croatian taekwondo athletes was similar to the results reported for elite female taekwondo athletes[1].

No significant differences occurred in mean values of the absolute and relative VO_{2max} between the two analyzed groups. However, mean values of the absolute and relative VO_{2max} of the Croatians were substantially higher than the VO_{2max} values of the elite female Czech[1] taekwondo athletes. Similar relative VO_{2max} values were reported by Rivera and associates[18] for the Puerto Rican elite female taekwondo athletes. The significant differences between the two groups were found in ventilatory anaerobic threshold (T_{vent}), whereas the differences in running speed at T_{vent} were not statistically significant (p=0.06). The group A had also significantly lower heart rate values at T_{vent}. All those differences (a rightward shift of the T_{vent} to a higher running speed at a lower heart rate) are typical markers of the endurance exercise induced adaptation[25] and indicate levels of athletes' aerobic performance[26]. Some authors[1,27] argued that aerobic abilities are not important for performance in taekwondo. The assertion can be hardly accepted even when the aerobic demands of one fight only are regarded (3 x 2 min), not to mention that during a competition an athlete usually participates in several fights (3–5, depending on a weight category) during a day. The authors of the present study consider that adequate aerobic capacity is indispensable because it enables relatively fast recovery between rounds and fights. High aerobic capacity also facilitates faster recovery during and after a training session. And it is well known that rapid recovery enables an athlete to reduce the rest intervals and to perform at higher intensities, especially in sports that demand many repetitions of a sport specific skill[28]. Magnitude of the differences in the T_{vent} and heart rate at T_{vent} and their confidence intervals (Table 2) indicate that the differences in aerobic performance are likely to be real and of practical importance.

The maximum running speed, scored during the progressive treadmill test, was significantly higher in the A group. Since the pronounced lactate accumulation occurs at the exercise intensities (running speed) of up the VO_{2max} level and higher, this variable does not indicate the maximal performance on the account of aerobic resynthesis of ATP[26]. Therefore, anaerobic lactic capacity has substantial influence on that physiological variable. The significance of anaerobic capacity to taekwondo performance was reported by Heller and associates[1] and Lehmann and associates[29]. Lehmann[30] reported that during female taekwondo fights maximal lactate values can be as high as 13 mmol/l and that mean lactate values are 9 mmol/l. In male taekwondo athletes those values are even higher[30].

The motor abilities results show that the A group was able to express significantly greater explosive power of leg extensors than the B group. Taekwondo kicking techniques of a ballistic nature and long-term performance of ballistic exercises results primarily in increased rate of force development (i.e. explosive power)[31]. Hence, the importance of explosive leg power in taekwondo performance is expectable. However, Heller and associates[1] reported that explosive leg power, measured by the squat jump test, was not a significant predictor of the performance rank in female taekwondo athletes. Since performance of squat jumps depends mostly on contractile power of muscles, it could be hypothesized that the ability to express maximal power in the stretch-shortening cycle (SSC) movements could be more important to taekwondo performance than the maximal power expression in the concentric-only movements. The results of the present study confirm this hypothesis. Namely, the significant differences in explosive power between the two groups were observed (apart from the 20m sprint) in the two counter-movement jump tests (CMJ and CMJA, Table 3). It must also be pointed out that A group had better results (2.6 cm ± 3.0 cm; $mean_{diff}$ ± 95% CI), although not statistically significant, in the RJ5 test which measures elastic (SSC) strength. The group A also had lower variability (1.9 cm vs. 3.5 cm) of the results in the RJ5 test.

The greatest significant difference between groups A and B were found in maximal mechanical power of leg extensors, measured by means of the 15-second jumping test. Additionally, power output (W kg^{-1}) during the 15-sec of jumping for the better group was similar to the results observed in Spanish elite male soccer players[32]. Since the short-term power output is an important component for soccer performance[33], we may say that the analyzed sample had highly developed anaerobic alactic power. Field observations have shown that a taekwondo fight is an intermittent activity, with 3–5 sec bouts of maximally intensive work which alternates with the low-intensity periods at an average ratio ranging from 1:3 to 1:4[1]. Activity of such nature imposes high demands on both anaerobic (alactic and lactic) performance capacities. High short-term anaerobic capacity is, therefore, of a primary importance for success in taekwondo.

Muscular endurance of the upper body (assessed by push-ups) appears to be of a minor importance in taekwondo performance. However, it seems that the magnitude of differences between the two groups in muscular endurance of the abdominal section (6.5 reps ± 6.7 reps; $mean_{diff}$ ± 95% CI), although not statistically significant, may be important. It is also obvious that the observed Croatian female taekwondo athletes have substantially higher muscular endurance of the abdominal section (55.1 reps/min) than the Puerto Rican ones (42.8 reps/min)[18]. Most sport scientists[13,28,34] and training experts agree that core (trunk region) strength and endurance play an important role in sport performance and injury prevention.

There were no significant differences between the two groups of participants in measures of absolute and relative maximal strength. However, it is evident that average absolute and relative strength values of lower extremities, especially in A group, are respectable. Comparing the scores of relative maximal leg strength of A taekwondo group to the norms for female athletes published by Chu[35], it becomes clear that the former group has excellent relative maximal leg strength. Since maximal strength is a component of power[36], its optimal development is essential for optimizing power performance. In sit-and-reach test, the two groups of female athletes did not differ significantly. However, the Croatian female taekwondo athletes achieved substantially higher results (55.8 cm) than the Puerto Rican (35.2 cm)[18] or Czech (37.9 cm)[1] athletes. These differences are probably the result of additional strength and conditioning training that the analyzed sample performed in previous years of training. The additional training included also various exercises aimed at improving flexibility of the low back region and hamstrings.

The observed female taekwondo athletes from the group A achieved significantly better results in the side step test than the athletes from B group. Like in many sports, taekwondo as well, quick performance of movements in multidirectional planes is crucial, together with maintaining balance, speed and precision of performance. Therefore, agility is an essential motor ability for successful performance in our sport[37]. Taking into account magnitude of the observed differences between the two analyzed groups of athletes, we can say, form the practical point of view, that the greatest weight in differentiating the successful from less the successful athletes can be attributed to measures of anaerobic alactic power, agility and explosiveness. Hence, the coaches are advised to pay special attention to anaerobic alactic power, agility and explosiveness in the process of selecting participants for taekwondo, as well as in designing training programs.

In summary, the present study indicated that the observed Croatian elite female taekwondo athletes had low levels of body fat, highly developed flexibility and high relative maximal strength. In contrast to the findings of the previous research, our study demonstrated that enhanced aerobic power might be of a practical importance from the aspect of sport achievements in competitive taekwondo. The members of the group A demonstrated a tendency to perform better in almost all the fitness variables. Based on the results of this study, it can be concluded that performance of female taekwondo athletes depends primarily on the following fitness variables: anaerobic and aerobic power, explosive power expressed in stretch shortening cycle movements and agility. Since taekwondo and karate use similar movement patterns and activate similar energy systems, fitness components relevant to success in taekwondo might also be of importance for performance in karate. Further studies are needed to establish relationships between fitness variables measured over the whole season and actual competitive success in taekwondo.

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STANJE UTRENIRANOSTI VRHUNSKIH HRVATSKIH ŽENSKIH TAEKWONDO BORACA

S A Ž E T A K

Cilj je ovog istraživanja bio utvrditi stanje utreniranosti (fitnes profil) vrhunskih hrvatskih ženskih taekwondo boraca te istražiti koje tjelesne, fiziološke i motoričke karakteristike najviše razlikuju uspješne od manje uspješnih natjecateljica. Trinaest državnih prvakinja podijeljeno je u dvije skupine prema dosadašnjim seniorskim međunarodnim rezultatima. Fiziološke karakteristike, uključujući maksimalni primitak kisika, izmjerene su sustavom COSMED Quark b^2 tijekom kontinuiranog progresivnog testa na pokretnoj traci. Motoričkim testovima procijenjene su: maksimalna snaga, eksplozivna snaga nogu, elastična snaga nogu, mišićna izdržljivost, agilnost i fleksibilnost. Razlike između uspješnih i manje uspješnih taekwondo sportašica utvrđene su t-testom za nezavisne uzorke. Uspješnije sportašice postigle su statistički značajno višu maksimalnu brzinu trčanja (15,8 ± 0,5 vs. 14,9 ± 0,7 km h^{-1}; $p<0,05$), te značajno viši ventilacijski anaerobni prag (41,4 ± 4,1 vs. 37,6 ± 2,0 ml kg^{-1} min^{-1}; $p<0,05$) pri značajno nižoj frekvenciji srca (166,8 ± 6,8 vs.171,0 ± 8,2 udaraca min^{-1} $p<0,05$) od manje uspješnih. Statistički značajne razlike također su utvrđene u tri testa eksplozivne snage ($p<0,05$), zatim u anaerobnoj alaktatnoj snazi ($p<0,01$) i lateralnoj agilnosti ($p<0,05$). Rezultati ovog istraživanja ukazuju na to kako uspješnost žena u taekwondou ovisi o slijedećim komponentama pripremljenosti: anaerobnoj alaktatnoj i aerobnoj snazi, eksplozivnoj snazi očitovanoj u ekscentrično-koncentričnom režimu rada mišića te o agilnosti.