

Special fitness of female karate practitioners

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Summary

Introduction. Physical fitness is one of the factors which determine the success in karate tournaments. This study is aimed at identification of a fitness profile of female karate practitioners.

Material and methods. A cross-sectional study design was employed. The examinations of 36 female karate practitioners were carried out during a pre-competition training camp. The mean age of participants was 23.75 ± 3.25 years whereas training experience was 8.96 ± 2.61 years. Mean body mass (Beurer scale, Germany) and body height (Martin's anthropometer) were 59.75 ± 5.97 kg and 166.39 ± 5.97 cm, respectively. Furthermore, the Special Physical Fitness Test (SPFT) battery was used. In cluster analysis, the results obtained from testing of European female champions were considered as model values. Two clusters were compared in MANOVA ($p < 0.05$).

Results. 23 subjects were grouped in Cluster 2, including 6 of 7 female athletes from the national team, whereas Cluster 1 ($n=13$) included only one national team member. Mean age, mean training experience, body height and mass and weight/height ratios were similar. Females in cluster 2 (compared to Cluster 1) were characterized by significantly shorter time of performing Rapid kicks, Agility test, Evasion actions and by twice greater number of push ups.

Conclusions. SPFT battery is useful in both testing motor preparation status of athletes and in scientific research. Since the results of the studies show the consistence of the time of intensive test exercise with time-motion structure of karate fight, interval training can provide a suitable means of improving aerobic and anaerobic capacity required from advanced karatekas.

Introduction

As Beneke et al. stated "Karate fight can be characterized as an acyclic activity profile that includes more or less frequent forward, backward and sidesteps and hopping movements, combined with short bouts of extreme techniques" [1]. Observation and analysis of tournament matches among European championship medal winners (Kyokushin karate style) showed that duration of one sequence of uninterrupted fight ranged from 2 to 93 s with an average of 21.1 ± 15.6 s. The mean duration of breaks between the sequences of continuous fight was 9.4 ± 7.7 s [2,3]. Other authors demonstrated in intermittent simulated karate fights which took 267 s on average that the ratio of activity-to-break times were 18 ± 6 s to 9 ± 6 s. In this kind of activity the contributions of aerobic, alactic and lactic sources were 77.8%, 16.0% and 6.2%, respectively [1]. The most frequent techniques were hand punches (seikentsuki and uraken-shita-uchi) and roundhouse kick (mawashi-geri) [2,3]. Normal duration of Kyokushin fight is 3 minutes, but the fight can be shortened due to a knock-down or injury. There is a possibility of two extensions of 2 minutes each [4].

The number of both male and female weight categories has been increased to 9 and 5, respectively [5]. The results obtained from fitness testing in female karate practitioners are particularly rare. Testing did include straight punches and roundhouse kicks which are typically used in karate fight (kumite). An indicator of speed endurance was maximum number of hand techniques and leg techniques performed during 20 and 25 s, respectively. Furthermore, an indicator of strength endurance was maximum number of the same techniques performed during 40 and 45 s, respectively. Positive and strong correlation was also found between gene expression level and speed endurance and strength endurance testing results [6].

The concept of the study

Contemporary men and women fight according to the same regulations [5]. Training sessions and sparring often occur in pairs, regardless of gender. However, under conditions of sports fighting, chances of winning are equal as women and men fight in different weight categories. It was assumed that, because of endurance and strength demands of the sport, female karate practitioners at the international competitive level

are likely to be characterized by a specific fitness profile. The abilities measured in these athletes in special fitness tests with longer duration and with resistance would be better compared to short-duration tests. Some female athletes who are not members of the national team might show similar fitness potential.

The main aim of this study is to determine fitness profile of female karate practitioners. The following two research questions were formulated: 1) Is there a specific physical fitness profile of a potential winner in karate fighting? 2) Are there subgroups of karatekas with distinct physical fitness profiles based on competence in karate?

Material and methods

Subjects and procedure

A cross-sectional study design was employed. The coaches and all the subjects ($n=36$) gave consent to participate in the study. The examinations of female karate practitioners were carried out during a pre-competition training camp. The standardized interview was used to record age, training experience, karate rank (kyu, dan) and level of achievement in the sport. The mean age of participants was 23.75 ± 3.25 years whereas training experience was 8.96 ± 2.61 years. Mean body mass and body height were 59.75 ± 5.97 kg and 166.39 ± 5.97 cm, respectively. The two groups were created using a criterion of sports skill level: Group A – national team ($n=7$), Group B – national level ($n=29$) (Tab. 1). The proportion of higher ranks (1 dan or 1 kyu) was higher in the Group A where lower ranks (2 and 3 kyu).

The Group A included three champions of the European Cup in weight categories of under 55 kg, under 65 kg and over 65 kg and one bronze medal winner in the category of 55 kg. The Group B included ranks of 2 and 3 kyu.

Measures

There was measured body mass (Beurer scale, Germany) and body height (Martin's anthropometer). Based on the above measurement, BMI and height-weight ratio (HWR) were calculated [7]. Special Physical Fitness Test (SPFT) battery was used according to its recommendations: The warm up before the test included a five-minute run at a moderate speed, followed by stretching exercises and slow exercises with equipment to help a subject to adjust to the exercise distance and other exercising partners [8].

The SPFT battery consists of the six tests [9] described in a study by [8]:

1. Hip turning speed test: the subject is tied with a belt above the right hip and adopts a fighting stance and turns

his hips to the left. This movement tightens the belt that is held by an assisting partner who stands in the rear (control), and then the subject withdraws his hip (and the belt becomes loose). At a signal, the subject performs 30 hip turns at maximum speed (and the yanks on the belt are counted). The time is measured accurately with a stopwatch. The materials necessary to conduct this test are a stopwatch and the belt.

2. Speed punches test: the subject adopts a fighting stance and performs a combination of the two punches: a straight left to the head (jodan-seiken-tsuki) and a straight right to the body (chudan-seiken-tsuki), not changing the hitting distance imposed. The punching pads on which 30 such combinations are performed (60 punches in all) are held at the constant height by the assisting partner. The time is measured accurately with a stopwatch.
3. Flexibility test is used to measure the maximum range of mawashi-geri roundhouse kicks, which are typically used during karate matches because they allow actions at the level of the head, trunk and lower extremities of the opponent. The best of the five measurements referred to the body height of the same person are recorded. Flexibility index = maximum range of kick/body height.
4. Rapid kicks test is commenced from a fighting stance with a leg put to the front and the test lasts up to the moment when the kicking foot is put on the ground after the last kick. The time to perform a series of 30 mawashi-geri kicks to kicking pad held by the coach at the jodan zone (head and neck level) is measured.
5. Agility test – this test consists in moving forward along a zigzag track on one leg and holding the knee of the raised leg at the waistline. Such a body position often occurs in defence as well as in attack. The time it takes the participants to cover the distance of 5 meters 6 times is measured, and the direction is changed by approximately 180 degrees after each lap. The time to cover the distance is measured.
6. Evasion actions test: the test starts from a fighting stance, and the subject walks backwards between lines that are about 8 m apart. The time the participants take to cover the track in the shape of a loop 6 times is measured. These tests resemble regular karate matches both in their content and duration.
7. Clinches frequently occur during fights, and then one ought to push the opponent away in order to execute punches and kicks. Therefore, additional control exercises to monitor local muscular endurance are used. The subject in forward base support (with feet leaning on a gymnastic bench) performs push-ups repeatedly with one hand clap-

Table 1. Characterization of the rank and sports skill level of female karate practitioners

Level	1Dan -1 Kyu	2 Kyu-3 Kyu	Row Total
Group A	7	0	7
Group B	5	24	29
Column Total	12	24	36

Chi-square with Yates' correction=13.855; Df=1; $P<0.001$; C=0.571

ping at one second. The maximum number of repetitions is recorded [2].

Statistics

In k-means clustering, the results obtained from tests of three European Cup female champions were considered as a model value (seed method and squared Euclidean distance were used). The female national team participants were counted for both clusters and then the mean values that represent-

ed different fitness profiles were used. Statgraphics Centurion v. XVI.I. software was used to compare the results by means of MANOVA. The ANOVA method was used if statistically significant differences were observed between the results of individual fitness tests. Post-hoc tests using Tukey's Honestly Significance Difference (HSD) were employed. The level of significance of the differences was set at $p < 0.05$. If the differences were significant, the effect size η^2 was calculated.

Table 2. Body mass and weight and results of special fitness tests of female karate practitioners

	Count	Average	Median	Standard deviation	F, p, η^2
Age (years)	36	23.75	23.00	3.25	
1	13	24.62	25.00	3.78	1.47, 0.244
2	23	23.26	23.00	2.86	
Experience (years)	36	8.96	9.00	2.37	
1	13	8.69	9.00	1.89	0.25, 0.620
2	23	9.11	9.00	2.63	
Body mass (kg)	36	59.75	59.5	5.97	
1	13	58.00	57.00	4.10	1.79, 0.190
2	23	60.74	60.00	6.68	
Height (cm)	36	166.39	165.00	5.97	
1	13	165.69	165.00	4.79	0.27, 0.606
2	23	166.78	167.00	6.62	
BMI (kg/m ²)	36	21.57	21.41	1.72	
1	13	21.14	20.96	1.31	1.32, 0.258
2	23	21.82	21.51	1.89	
HWR (cm/kg ^{0.33})	36	42.63	42.75	1.27	
1	13	42.84	43.13	1.11	0.55, 0.462
2	23	42.50	42.43	1.37	
Hip turning speed (s)	36	11.93	11.94	2.01	
1	13	11.48	11.31	1.99	1.01, 0.321
2	23	12.18	12.00	2.02	
Speed punches (s)	36	10.31	10.00	1.99	
1	13	10.42	10.25	1.11	0.06, 0.803
2	23	10.24	9.40	2.37	
Flexibility index (cm/cm)	36	1.09	1.09	0.04	
1	13	1.09	1.09	0.04	0.02, 0.877
2	23	1.09	1.09	0.04	
Rapid kicks (s)	36	18.90	18.50	1.93	
1	13	20.35	19.63	2.26	16.65, <0.001, 0.329
2	23	18.08	18.00	1.09	
Agility (s)	36	15.27	15.21	1.64	
1	13	16.82	16.36	1.59	36.69, <0.001, 0.519
2	23	14.39	14.30	0.83	
Evasion actions (s)	36	42.97	42.70	3.72	
1	13	45.86	45.20	3.465	18.37, <0.001, 0.351
2	23	41.34	41.50	2.78	
Push-ups (n)	36	14.14	13.00	7.32	
1	13	9.38	9.00	4.43	11.04, <0.002, 0.245
2	23	16.83	18.00	7.33	

BMI – body mass index, HWR – height-weight ratio

Results

The means, standard deviations and medians for the overall sample are presented in Table 2.

The MANOVA test revealed significant differences between Clusters 1 and 2 (Wilks' lambda = 0.243, $F=9.01$, $p<0.001$). The Cluster 2 grouped the most of the subjects, including 6 members of the national team. They were characterized (compared to Cluster 1) by significantly faster performance of Rapid kicks, Agility test, Evasion actions and by twice greater number of Push-ups.

Discussion

Short-term, intensive bouts of exercise used in SPFT battery use chiefly alactic anaerobic (ATP-PCr) and lactic (glycolytic) anaerobic systems. Regeneration of these energy sources is possible through aerobic processes, which are intensified in the intermittent exercise [1,10]. The aerobic sources contribution during maximal work of from 30 s to 60 s was from 40% to 50% [1], whereas in Wingate 30 s test it was 18.6% [11]. Undoubtedly, highly intermittent effort, such as competitive karate, causes that the relative contribution of oxidative pathways to the resynthesis of ATP could be even higher [12]. In this context, the notion that aerobic energy sources dominated over anaerobic sources in karate fights with duration of 180 s to 240 s seems to be interesting [13]. The attempt of construction of a karate-specific aerobic test based on a multi-stage Leger test failed to be entirely successful [14]. Although the test included the techniques typical of karate fight, such as e.g. straight punches and roundhouse kicks, it took over 19 minutes [12]. Another Karate-Specific Aerobic Test (KSAT) had also long duration (14 to 17 minutes) and was also continuous [15], which was not consistent with time-motion structure in karate fights [1-3,16].

The six physical fitness trials were supplemented with push-ups and used in large karate male group [8,9]. The Special Physical Fitness Test (SPFT) battery is karate-specific. It is (a) replicable i.e. accurate for diagnosis of physical fitness preparation; (b) useful in monitoring training effects; (c) able to accurately discriminate competitors at different sports skill level and characterized by very high accuracy; (d) correlated with the results obtained from testing of general physical fitness and coordination abilities; (e) connected with the somatic build of the athlete; and (f) it defines the normative data for males [8]. No studies before have presented SPFT battery results in female karate athletes (karatekas). It is important that SPFT battery simulates the most frequent technical and tactical actions used in the real fight: straight punches in Speed punching test and roundhouse kicks in Rapid kicks test, typical methods of moving in Agility and Evasion actions tests, pushing actions (as in Push-ups test) typical for clinch release and increase distance which is necessary before next attack (punch or kick) and, finally, kicking range (Flexibility index standardized to body height). It is also important that the duration of these karate-specific exercise is consistent with the duration of the intensive activity demonstrated in time-motion analysis of karate fights [1,16].

In a study of female karate practitioners, the karate-specific exercise was classified (based on duration time) as speed endurance and strength endurance type [6]. This study is the first attempt to provide information concerning the results obtained from SPFT battery in female karate practitioners. The individual characteristics defined by two European champions caused inclusion, based on the principle of similarity (Cluster 2), of the specific fitness profiles which were characterized by the majority of female national team members (6 out of 7) and 17 athletes of national competitive level. The results showed significant differences between the Cluster 1 and Cluster 2 in four out of 7 tests in SPFT battery, i.e. Rapid kicks, Agility, Evasion actions and Push-ups. All these tests took longer than 14 s and were characterized by combined contributions of speed endurance (Rapid kicks, Agility), strength endurance (Evasion actions) and local strength endurance (Push-ups). The atypical fitness profile of gold medalist in 55 kg weight category was a pattern for seed/building the Cluster 1. The attempts of explanation of this phenomenon should involve a comprehensive identification of the level of preparation of the athletes, since competitive readiness is not only about the diagnosis and the scores in fitness tests (motor preparation) but also controlling body build and composition according to weight category [17,18], technical, tactical [2] and psychological preparation as well as motivation [2,19] or ability to cope with stress under competitive conditions. The excessive level of stress generated during high-level competition, during selection matches, in the presence of a stronger opponent and a crowd of fans, refereeing mistake might negatively affect the quality of actions performed in both attack and defence [19]. The saliva cortisol concentration in finalists showed higher competitive stress than in the third and fourth placers [20]. In difficult, rapidly changing situations during a fight, the process of decision-making can be disturbed. In such cases, motor preparation is less important while the leading role is taken over by tactical preparation, which is connected with psychological preparation of the athlete [19]. Although the model of special fitness in female champions in the weight category of 55 kg might confirm this compensation pattern, it remains uncertain whether it was present in the athletes of lower competitive level (Cluster 1). If this was the case, the athletes would stand a chance of taking part in the continental championships.

Conclusions

1. SPFT battery is useful in both testing motor preparation status of athletes and in scientific research.
2. Since the results of the studies show the consistence of the time of intensive test exercise with time-motion structure of karate fight, interval training can provide a suitable means of improving aerobic and anaerobic capacity required from advanced karatekas.
3. The results of the cluster analysis are the basis for planning training in consideration of the fitness profile of female karate practitioners (their strength and weaknesses of preparation).

4. With similar level of fitness-related preparation of karatekas, a comprehensive training control will be necessary in order to identify the factors which ensure best possible competitive readiness.

Practical implications

The finding of the investigations of special fitness using the SPFT battery resulted in identification of the fitness profiles represented by female karate practitioners. Individual performance can be compared between the athletes as well as in the same athlete in order to monitor the changes which occur in the sub-period of special preparation. Sports skill level and tournament rank were correlated with elevated risk of injury [21]. So, the performance should also be tested and

compared after sustained trauma at the final of rehabilitation program. In advanced karatekas, interval training seems to be worth recommendation as it is likely to simulate the conditions of time-motion analysis in karate fight i.e. activity-to-break ratio (2:1). Tabata et al. proved that one set of 6-7 bouts of 20-s exercise at an intensity of approximately 170% of the subject's maximal oxygen uptake (VO₂max) with a 10-s rest between each bout stressed mostly maximally the both the anaerobic and aerobic energy releasing systems. It works effectively [22].

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