# Testing motor fitness in karate

**Authors' Contribution:**
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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## Abstract

**Background and Study Aim:** Evaluation of sport skills **test** can be very useful tool for coach practice. The aim of the present paper was: (a) to evaluate the reliability and accuracy of the **Specific Physical Fitness Tests** (SPFT) (b) to review the results of **karate** athletes who represent different weight categories, and who are at different stages of schooling; (c) to establish grading criteria of physical fitness preparation.

**Material/Methods:** The reseach was conducted among 219 Kyokushin karate players, whose profiles were presented as $\bar{\chi}$ ±SD and their main characteristics were the following: age 26.8±4.67 (19–39) years, body mass 75.2±8.35 (50–97) kg and body height 176.4±5.67 (160–196) cm. The value of the BMI amounted to 24.1±2.17 (17.9–29.4) kg/m$^2$. All the subjects of the research had training experience of 10.5±3.71 (4–20) years and their degree of proficiency ranged from 4$^{th}$ kyu to 3$^{rd}$ dan. The physical fitness trials proposed by Story (1989) included: hip turning speed, speed punches, flexibility, rapid kicks, agility, and evasion actions. It was supplemented by a test of local strength endurance, composing a battery of the SPFT, which was implemented by first of the authors between 1991 and 2006.

**Results:** SPFT is characterized by high reliability and it can be used to diagnose the physical fitness preparation and monitor the individual results of training. It discriminates accurately competitors with different sports level and it is characterized by very high accuracy, it is correlated with the test results of motor general physical fitness abilities and coordination abilities as well as it is connected with the somatic build of the athlete. The performance classification table was developed on the basis of our research.

**Discussion:** Results obtained in SPFT were shortly discussed.

**Conclusions:** The collected results of our research allowed us to come to, the conclusion: The table can be applied not only to assess karate fighters, but also adepts in taekwondo, kick-boxing, ju-jitsu, hapkido or other mixed martial arts.

**Key words:** karate • Specific Physical Fitness Tests • test

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**Karate** – a contemporary sport in which competitors are participated in fights *Kumite* or formal exercises *Kata* and breaking boards *Tameshiwari*.

**Specific physical fitness** – skill-related fitness; the ability of a person to function efficiently and successfully in a given sport.

**Test** – an examination designed to reveal the relative standing of an individual in a group.

## Introduction

Karate fight is characterized by changeable effort intensity, i.e. periods of maximum work alternate with periods of lower intensity or with short intervals. When analyzing the course of karate matches during the European championships it was found that from among 1198 sequences of continuous work 11.4% lasted from 1–7 seconds, 79.5% from 8 to 50 seconds and 9.1% of the total number of the recorded sequences of fight lasted from 51 to 120 seconds [1]. Additionally, in a typical karate kumite match, athletes perform in 2:1 effort by pause relationship (more specifically 18±6s of effort with 9±6s of interval) resulting in 16.3±5.1 high intensity actions during the whole match or 3.4±2.0 actions per minute lasting 1 to 3 s each [2]. In a recently published study [3] a similar action time (0.3±0.1 s to 2.1±1.0 s) was found, resulting in a total high intensity action time of 13.3±3.3 s and 19.4±5.5 s in 2-min and 3-min matches, respectively. As consequence of such effort by pause

relationship and action duration, the karate match is mainly aerobic in nature (77.8±5.8%), although the decisive actions are anaerobic alactic and less prevalent (16.0±4.6%) [2]. In fact, the anaerobic alactic contribution represents the same percentage that the time of high intensity actions represents relative to total match duration (16.6%). Furthermore, during interval exercises the following factors influence physiological responses: 1) effort intensity, 2) intensity of the recovery processes, 3) effort duration, 4) recovery duration, 5) ratio between effort and recovery [4]. Thus, considering these factors and the studies presented above, karate matches may be considered as physical activities wherein the processes involving aerobic metabolism predominate, but the anaerobic alactic metabolism is responsible for the actions which result in scores. Moreover, aerobic fitness can become important during prolonged matches or during competitions where the competitor has several matches in the same day [2].

Karate athletes move about in various directions on a square mat and attack their opponents with both upper and lower extremities in different moments of the match. Observations have shown that *Mawashi-geri* (round-house) kicks are the most effective kicking technique, whereas straight blows with an upper extremity (*Chudan-seiken-tsuki*) are the most effective punch technique [5]. Although karate has these specific physical demands, the testing of karate players is limited to few tests [6,7] or tests battery [8]. Michielon et al. [6] adapted Specific Judo Fitness Test [9,10] and modified it with karate techniques in the evaluation of the athletes. The subject has to shuttle and to perform a *Sanbon-tsuki* technique instead of judo throw *Ippon-seoi-nage*. Story [8] designed a method of testing motor efficiency in karate, but no results are presented on this paper.

## Description of the SPFT and its rationale

The warm up includes a five-minute run at a moderate speed, then stretching exercises as well as slow exercises with equipment to help to adjust oneself with the exercise distance and with other exercising partners.

The SPFT battery consists of six tests [8]:

1. Hip turning speed test: the subject is tied with a belt above the right hip, and then he assumes 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 executes 30 hip turns at his 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: stopwatch and belt.
2. Speed punches test: the subject assumes a fighting stance. Every subject executes a combination of 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 executed (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* 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 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 lowered 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* (head and neck level).
5. Agility test – this test consists in movement 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 defense 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 was 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.
7. Clinches frequently occur during fights, and then one ought to push the opponent away in order to execute punches and kicks. Therefore, an additional control exercises to monitor local muscular endurance. The subject in forward base support (with feet leaning on a gymnastic bench) repeatedly performs push-ups with one hand clapping at one second. The maximum number of repetitions is recorded [1].

These tests resemble regular karate matches both in their content and duration. The complex motor tasks the subjects must perform during Specific Physical Fitness Tests are presented in Figures 1–5.

The premises for this choice of movement technique were as follows:

(a) Mechanics of movement because hip turns occur both during attacks executed with upper extremi-

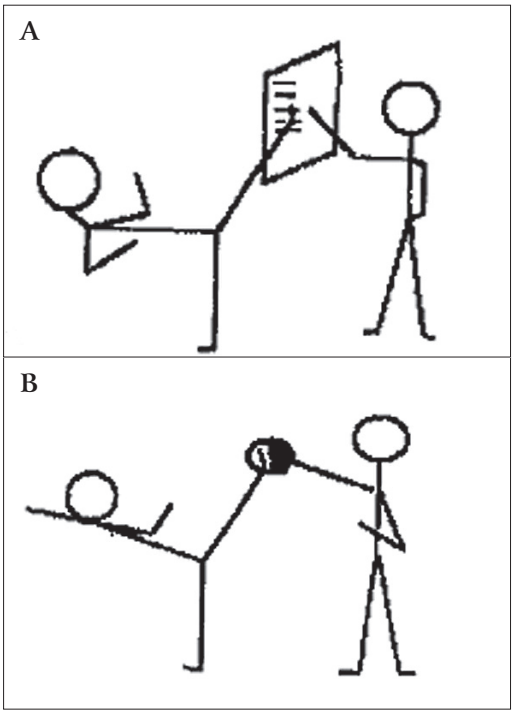


**Figure 1.** Schematic representation competitors' silhouettes during Specific Physical Fitness Tests (**A**). Measurement of the *Mawashi-geri* kick in the flexibility test (**B**). Kick on kicking pad held by the assisting partner during the rapid kicks test.

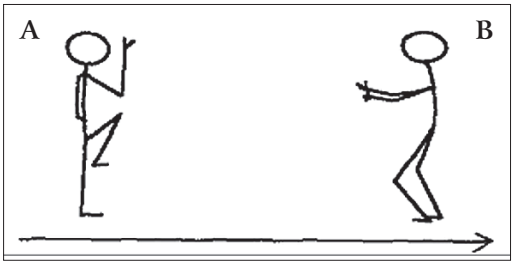


**Figure 3.** Basic stances used during the agility tests (**A**) and evasion actions (**B**).

ties, and lower extremities. They are also an integral part of actions in defense techniques and they reduce the impact force on the abdomen.

(b) Straight punches and *Mawashi-geri* kicks occur during competitions and they are the main forms of attack during competition matches, which results in the majority of athletes executing them properly.

(c) The contest area is a limited square space. During the tests of agility and evasion actions the subject moves both forwards and backwards, changing direction according to predetermined track.

(d) The duration of tests has been based on the results of studies carried out during regular competitions, though each of the tests lasts shorter than an average fight.

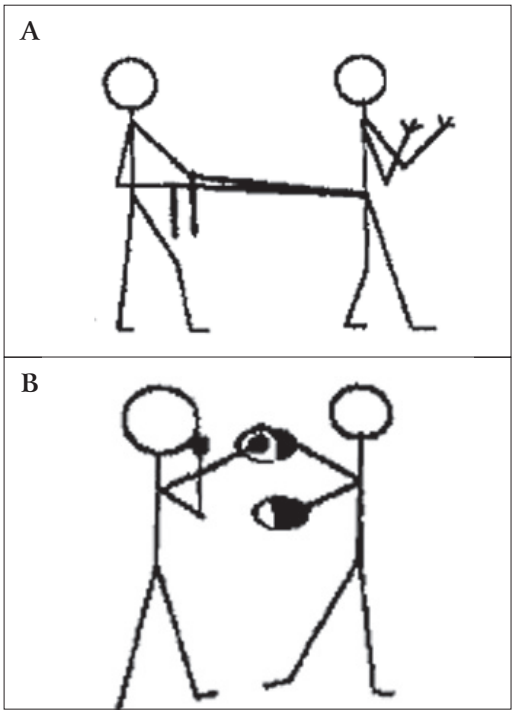


**Figure 2.** (**A**) counting of the number hip turns with the use of the "belt" method (**B**). combination of punches on punching pad held by the assisting partner.

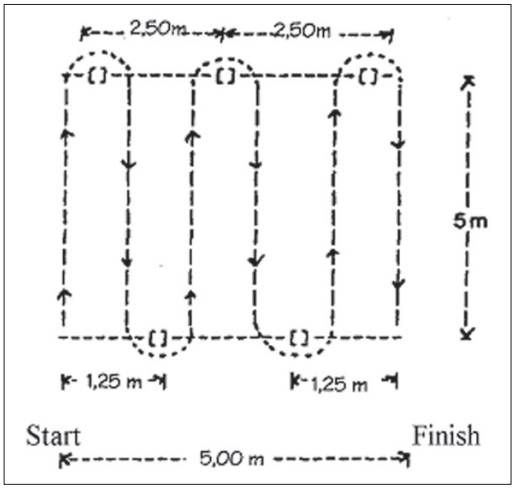


**Figure 4.** Schema of the design of the track for the agility test "zigzak" (according Story 1989).

The aim of this study was: (a) to evaluate the reliability and accuracy of the SPFT; (b) to review the results of karate players who represent different weight categories, age and who are at different stages of achievement schooling; (c) to establish grading criteria of physical fitness preparation.

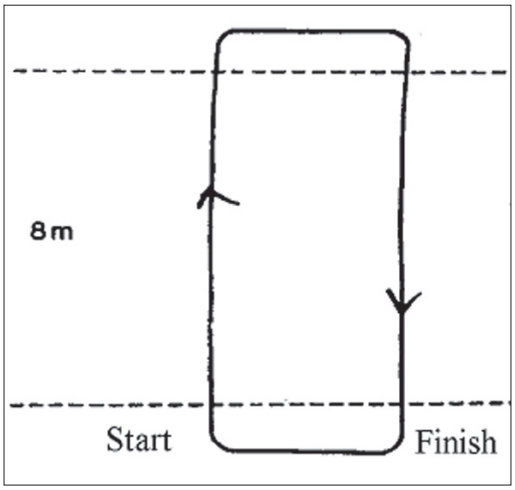


**Figure 5.** Schema of the motion path of the competitor during the evasion action test (Story 1989).

## Results

### The SPFT battery and the reliability of its results

One of the most important aspects related to the authenticity of any test is its reliability [9]. The SPFT battery has a good repeatability. During one of the first studies [11] the correlation coefficient of the results (test-retest; n=48) was high and during every test it amounted to: 0.82 – hip turning speed, 0.96 – speed punches, 0.99 – flexibility index, 0.93 – rapid kicks, 0.82 – agility, 0.82 – evasion actions.

Our finding was confirmed by Michielon et al.[12]. Twelve mid-high level karate athletes (1st Dan to 3rd Dan, six kata and six kumite specialists) volunteered for the study (Mean ±SD, age 22.0±2.0 years, weight 71.0±7.1 kg, height 175.0±0.05 cm, BMI 22.9±1.3). Sterkowicz's protocol [1] was applied to collect data regarding both dominant and non-dominant limbs, such as: i) Hip Turning Speed (HTS); ii) Speed Punches (SP); iii) Hip Flexibility Index in the kicks (HFI); iv) Rapid Kicks (RK). Each test was executed five times (test) and repeated one week later (re-test). The the kick's height reached by the back leg against a suspended training bag was measured, then the index was calculate as hT/hA, where hT is the average height of the five kicks and hA is the athlete's stature. No differences were found between test and re-test (intra class correlation coefficient >0.90). No differences were found between dominant and non-dominant limbs ($p>0.05$). No differences were found between kata and kumite athletes ($p>0.05$). Italian authors concluded all tests executed appear to be repeatable, then suitable to evaluate the training effects in mid-high level karate's athletes. The practice of karate leads to a well balanced development and control of both the dominant and the non dominant limbs, then athletes are able to perform similar effective actions regardless to the guard position. Even if *Kata* is characterized by more symmetrical actions than *Kumite* (where scores are mainly attained by the employment of the dominant limbs) the tests proposed showed there are no differences between the two specialties [12].

### The validity, i.e. correlation of the SPFT with other tests and with the external criterion

Specific tests cannot be solely tool in training control. The results estimated by means of the SPFT were correlated with the results measured by other renowned tests. From the point view of sports-practice, especially the one connected with preliminary selection for karate, it is important to find a moderate correlation between the results of all-round physical fitness tests and the results of specific physical fitness tests ($r>0.40$). Some significant relations were found, namely between the time to perform the agility test with the distance of the standing broad jump ($r=–0.43$) and the time of the 50-meter run ($r=0.31$), as well as between the speed of *Mawashi-geri* kicks and the time of the 50-meter run ($r=0.43$). The relation between the results of the broad jump with hip turning speed was weaker ($r=–0.32$) [13]. Moderate r-values just show that practical coach should use both results of the general physical fitness tests and the SPFT.

In another study [14] the relation between the test results of motor coordination abilities and the SPFT was analyzed. The canonical correlation coefficient between the two sets of variables amounted to $R=0.97$ ($p<0.001$). The first canonical variable was more saturated (>0.30) by the results of the tests involving the frequency of movements (i.e. jumps over the bar of a gymnastic bench and the frequency of movements with the upper extremity) as well as by the coefficients describing static balance, whereas the second canonical variable was more influenced by agility, rapid kicks and flexibility index. Additionally, in another study [11] a correlation was found between the results of 200-meter obstacle test at the test results involving physical fitness center and flexibility (0.52), evasion actions (0.46) as well as agility (0.32).

Given the above facts, it can be said that the results of the SPFT can accurately diagnose, i.e. explain the common value of variance as the renowned tests used to control the training process of[1] tests of endurance and motor coordination abilities available for people who are not athletes and correlated with the SPFT could be a good tool to perform choice and selection for karate.

The research on the SPFT that was supplemented by tests involving maximal anaerobic power and aerobic ca-

**Table 1.** The results of control exercises performed by karate players, with regard to their weight categories.

| Weight Category/ Variables | Hip turning speed (s) | Speed punches (s) | Flexibility index | Rapid kicks (s) | Agility (s) | Evasion actions (s) | Push-ups (n) |
|---|---|---|---|---|---|---|---|
| | $\bar{x}$±SD | $\bar{x}$±SD | $\bar{x}$±SD | $\bar{x}$±SD | $\bar{x}$±SD | $\bar{x}$±SD | $\bar{x}$±SD |
| –70 kg (n=12 | 11.9±0.84 | 10.1±0.95 | 1.1±0.07 | 18.7±1.31 | 15.8±0.86 | 41.2±3.49 | 38.7±8.41 |
| –80 kg (n=17) | 11.9±1.22 | 10.7±1.64 | 1.1±0.05 | 19.2±1.27 | 15.8±1.36 | 40.8±2.74 | 38.1±9.34 |
| +80 kg (n=10) | 12.6±1.69 | 11.8±2.93 | 1.1±0.05 | 19.7±1.51 | 16.2±0.67 | 40.9±4.60 | 37.7±9.96 |

**Table 2.** Performance classification according to hip rotation, speed punches, flexibility index, rapid kicks, agility, evasion actions, and push-ups with clapping hands.

| Classification (grade) | Hip turning speed (s) | Speed punches (s) | Flexibility index | Rapid kicks (s) | Agility (s) | Evasion actions (s) | Push-ups (n) |
|---|---|---|---|---|---|---|---|
| Excellent (5) | ≤10.0 | ≤8.7 | ≥1.15 | ≤17.2 | ≤13.4 | ≤37.8 | ≥44 |
| Good (4) | 10.1–11.9 | 8.8–10.4 | 1.08–1.14 | 17.3–19.2 | 13.5–14.5 | 37.9–41.0 | 31–43 |
| Regular (3) | 12.0–13.0 | 10.5–11.5 | 1.06–1.07 | 19.3–20.0 | 14.6–15.1 | 41.1–43.9 | 25–30 |
| Poor (2) | 13.1–16.0 | 11.6–16.0 | 0.98–1.05 | 20.1–23.4 | 15.2–16.3 | 44.0–50.2 | 10–24 |
| Very poor (1) | ≥16.1 | ≥16.1 | ≤0.97 | ≥23.5 | ≥16.4 | ≥50.3 | ≤9 |

pacity [13] gave rise to a question, whether on the basis of the of test results describing how a given person executed a given motor task it is possible to foresee their actual proficiency in karate? The multiple correlation coefficient amounted to R=0.92. The corresponding coefficient of determination $R^2$=0.81 (F=30.95, p<0.001). The common variance amounted to 81%, so accuracy of forecast in the group of the competitors may be regarded as high[2]. The simplified model of the linear regression equation consisted of the following elements:

$$\acute{y} = -8.703 + 19.8166 * \text{flexibility} - 0.00398194 * \text{Cooper}$$

This dependence was confirmed by the correlation between the rank of sports level criterion and the results of the flexibility test as well as the distance in Cooper's running test (0.69 and –0.53). A significant relation was also found between the evaluation of proficiency and the percentage of the area of contractile muscle fibers in the lateral head of the quadriceps femoris (0.62) and the time it took to execute 30 *Mawashi-geri* kicks (–0.54).

### Diversification of karate fighters of different weight and age categories as well as of different levels of proficiency

The relations that occur between the anatomical structure and functions of the body account for the division of competitors into different weight categories [16]. The comparison of the results obtained during our previous study [13] revealed a tendency towards a deterioration (it was not statistically significant) of the SPFT average results in the medium and heavy weight categories in relation to the lightweight category. This phenomenon occurred during the following tests: hip turning speed, speed punches, rapid kicks, agility, and local muscular endurance (as measured by number of push-ups).

The speed measured by the time to perform combinations of hip turnings, straight punches, and 30 *Mawashi-geri* kicks increased in Groups of karate players with proficiency ranging from 4$^{th}$ *kyu* to 2$^{nd}$ *kyu* and it decreased in the group of those with proficiency ranging from 1$^{st}$ *kyu* to 1$^{st}$ *dan*. The absolute range of kicks was the greatest in the group with 2$^{nd}$ *kyu*. The coefficient describing the flexibility corresponding to body height in groups with the higher degree of proficiency was greater than in the less advanced karate fighters (4$^{th}$–3$^{rd}$ *kyu*). The time to cover the distance during the tests of agility and evasion actions became shorter and shorter in groups with the degree of proficiency ranging from 4$^{th}$ to 2$^{nd}$ *kyu*. This tendency disappeared in competitors with the degree of proficiency ranging from 1$^{st}$ *kyu* to 1$^{st}$ *dan*. It is necessary to emphasize that the subjects from this group were the heaviest and the oldest. During the control exercise involving local strength endurance the best results were achieved by group with the degree of proficiency rang-

1. For diagnostic purposes one can use tests whose discrimination is not less than 0.3, whereas for prognostic purposes – not less than 0.6 [15].
2. According to Kirkendall et al. [17] the multiple correlation coefficient for a battery of motor tests with sports-ranking (or with other external criterion) should amount at least to R = 0.80.

ing from 1st *kyu* to 1st *dan*. After the calculation of the results in T scale distinct differences in physical fitness profiles were discovered, which depended on the degree of proficiency in karate. The superiority of a contestant of championship class (1st *dan*) over a less advanced one (4th *kyu*) was quite noticeable in the results of the tests of rapid kicks and agility [1].

**Performance classification table**

The greatest difficulty for specialists, who use the SPFT, is how to classify an athlete on the basis of the results obtained by him or her. Following the suggestions formulated in the literature concerning methodology [15,17] on how to design tests and how to evaluate physical fitness this paper was developed to help and meet the expectations of instructors and coaches[3] by proposing a method of classifying the karate players who were tested according to the SPFT battery.

Table 2 was developed on the basis of a research on 219 *Kyokushin* karate fighters whose profiles were represented as $\bar{\chi} \pm SD$ and their spread was as follows: age 26.8±4.67 (19–39) years, body mass 75.2±8.35 (50–97) kg and body height 176.4±5.67 (160–196) cm. The value of the body mass index (BMI) amounted to 24.1±2.17 (17.9–29.4) kg/m$^2$. All the subjects had a training experience of 10.5±3.71 (4–20) years and their degree of proficiency ranged from 4th *kyu* to 3rd *dan*. The classification grades were done on the basis of their results frequency (20 percent of all athletes in each one).

Grades from 1 (very poor) to 5 (excellent) may be applied in the evaluation of one competitor or comparisons of two competitors (see the Table 2). The coach can monitor changes in the profile of an individual athlete, too.

## Discussion

Since the time when the testing method of efficiency in karate was described [8] it has been applied in different training groups and implemented by the first author during courses for *Kyokushin* karate instructors between 1991 and 2006, as well as Polish National Team [18]. The SPFT battery is easy to use under conditions available in training gyms and the results it yields can be used to control the physical preparation of athletes.

The SPFT battery is karate specific. It is: (a) replicable i.e. accurate for diagnosing physical fitness preparation; (b) useful in controlling the effects of training;(c) able to accurately discriminate competitors with different sports level and it is characterized by very high accuracy; (d) correlated with the test results of motor general physical fitness abilities and coordination abilities; (e) connected with the somatic build of the athlete.

## Conclusion

The performance classification table can be applied in similar sports where punching and kicking techniques are applied during matches, i.e. in Taekwondo, kickboxing, ju-jitsu, and Hapkido or mixed martial arts.

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3. The author is involved in the education of karate instructors and coaches.