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FUNCTIONAL DIAGNOSTICS OF KARATE ATHLETES

FUNKCIONALNA DIAGNOSTIKA KARATEISTOV

Abstract

The paper deals with functional diagnostic of karate athletes in different ages by means of the laboratory tests. The results of long-term studies showed as a suitable method for the assessment of multi choice reaction time the agility test, for explosive power of lower limbs a ten and sixty-second tests on the jump ergometer, for strength a ten-second test on the isokinetic cycle ergometer, for anaerobic abilities a thirty-second load on the treadmill in the form of tethered running, and for aerobic capabilities the spiroergometric examination. Such an evaluation of sport performance in karate athletes based on functional tests can contribute to more effective training planning with subsequent enhancement of their performance.

Key words: karate, functional diagnostics, aerobic abilities, anaerobic abilities, explosive power

Izvleček

Članek opisuje funkcionalno diagnostiko različno starih športnikov karateistov, ki je bila ugotovljena z uporabo različnih testov. Rezultati dolgotrajnih študij so pokazali, da so primerne metode za ocenjevanje izbirnega reakcijskega časa test spretnosti, za eksplozivno moč nog pa deset in šestdeset sekundni testi na skakalnem ergometru. Metoda za ocenjevanje moči je deset sekundni test na izokinetičnem cikličnem ergometru, za anaerobno sposobnost trideset sekundna obremenitev na tekalni stezi pri teku z omejeno hitrostjo in za oceno aerobne sposobnosti spiroergometrijski pregled. Takšno ovrednotenje športne sposobnosti športnikov karateistov na podlagi funkcionalnih testov lahko pripomore k bolj učinkovitemu načrtovanju vadbe in posledično izboljša njihovo zmogljivost.

Ključne besede: karate, funkcionalna diagnostika, aerobne sposobnosti, anaerobne sposobnosti, eksplozivna moč

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Introduction

Karate involves basics, kata and kumite. Basic techniques such as punching, kicking, blocking and striking are practiced either in a stationary position or with body movements in various formal stances. Kata is a set of forms in pre-established sequences of defensive and offensive techniques and movements. Kumite is the execution of defensive and offensive techniques while one is freely moving against an opponent (Imamura, Yoshitaka, Uchida, Nishimura, & Nakazawa, 1998). Such a training itself is prevailingly anaerobic due to the fact that karate practices are characterized by short spells of high intensity exercises interrupted by milder periods of active standing rest (Imamura, Yoshitaka, Uchida, Nishimura, & Nakazawa, 1998), which is evident as an increase of heart frequency and blood lactate. In competition sparring the heart frequency was found to be 180 – 199 beats/min and the blood lactate 4.5 – 6.5 mmol/l. During the training unit higher values (5.8 – 12.5 mmol/l and above 200 beats/min) were observed based on chronometric measurement (Zemková, Dzurenková, & Longa, 1997).

These findings are congruent with the study of Imamura, Yoshimura, Uchida, Tanaka, Nishimura and Nakazawa (1996), who found the mean heart rate during the 20 consecutive karate sparring matches (each of 2 minutes duration) to be 191.8 ± 9.4 beats/min. Similarly, Šebej and Klementis (1982) have documented heart rate above 180 - 200 beats/min following competitive kumite. During sparring, basic techniques (Imamura, Yoshimura, Nishimura, Nakazawa, Nishimura, & Shirota, 1999) and kata performance (Shaw & Deutsch, 1982; Zehr & Sale, 1993) even higher heart responses were elicited for given % VO_{2max} than during the treadmill run. In relation to this, the mean percent of maximal oxygen uptake and heart rate during sparring and basic techniques has been found (Imamura, Yoshimura, Nishimura, Nakazawa, Nishimura, & Shirota, 1999) to be above the accepted threshold (60% of HR_{max} or 50% of VO_{2max}) and in kata and 70 min of karate training the mean % HR_{max} was slightly above and % VO_{2max} slightly below the threshold.

Besides anaerobic abilities, the principal capabilities of karate performance are also multi choice reaction time, explosive power, and strength (Zemková, 1999). The relevant assessment should therefore be considered an integral part of functional evaluation of karate athletes. However, current literature provides only scarce evidence concerning their precise testing in laboratory conditions.

Hence, the aim of the study was to present the results of long-term functional diagnostics of karate athletes of different ages, namely by an agility test used for the assessment of multi choice reaction time, ten and sixty-second tests on the jump ergometer for explosive power of lower limbs, a ten-second test on the isokinetic cycle ergometer for strength, a thirty-second load on the treadmill in the form of tethered running for anaerobic abilities, and a spiroergometric examination for aerobic capabilities.

Method

Participants

Altogether 65 elite karate athletes of the National Karate Team of different ages participated in the present study. The detailed description of the sample is presented in Table 1.

Table 1: Description of the sample

number of participants	*age (in years)* *M (SD)*	*height (in cm)* *M (SD)*	*weight (in kg)* *M (SD)*
12	8.9 (1.1)	136.6 (8.4)	32.9 (8.8)
8	12.3 (0.9)	152.3 (4.4)	42.9 (5.8)
17	16.5 (1.4)	176.4 (6.4)	65.9 (8.8)
28	23.3 (3.5)	178.1 (5.0)	72.9 (7.6)

Instruments and procedure

The subjects were examined by the agility test, jumping ergometry, isokinetic cycle ergometry, tethered running on the treadmill, and spiroergometry.

In the agility test used for the assessment of multi choice reaction time subjects had to touch with either left or right lower extremity one of the four mattresses located in four corners inside of the 80 cm square. Mattresses had to be touched in accordance with the location of stimulus in one of the corners of the screen. Computer based system FiTRO Agility Check was used to generate the stimuli and measure the reaction times (Hamar & Zemková, 1998).

For the evaluation of the explosive power of lower extremities and endurance 10 and 60-second tests on the jump ergometer were used. The main task of the subject was to perform the highest jump possible while they held the hands fixed on the hips to minimise the influence of upper extremities. The system consists of a special contact switch mattress connected to a computer by means of a special interface. The power output in the active phase of take off (Pact) was quantified in both tests, and in 60-second test the fatigue index was calculated as well. The power in the active phase of take off in fact expresses the capability to take off with the highest intensity in the shortest time possible. According to research data, this capability is to a high degree conditioned by the proportion of fast muscle fibres (Hamar & Tkáč, 1995).

For the assessment of the strength abilities of lower extremities the test consisting of 10 seconds "all-out" cycling bouts on the isokinetic cycle ergometer at the revolution rates from 40 to 140 rpm was used (Hamar, Gažovič, & Schickhofer, 1994).

The 30-second "all-out" tests on the isokinetic cycle ergometer and on the treadmill in the form of tethered running were applied for the assessment of anaerobic abilities (Hamar, Baron, Bachl, Tschan, Tkáč, Kampmiller, & Komadel, 1992). During tethered running the subjects, in addition to running, had to pull a rope attached to the waist belt and tensometer fixed on the wall behind the treadmill.

The aerobic capabilities were measured with increasing load by the cycle spiroergometry at vita maxima. The oxygen pulse and maximal oxygen uptake were quantified.

RESULTS

The results of the agility test showed (see Figure 1) that karate athletes in comparison with athletes of other martial arts (Zemková & Hamar, 1998) achieved similar reaction time (M=339.4 ms; SD=33.4 ms) as the fencing performers (M=336.6 ms; SD=17.4 ms), however significantly (p < 0.01) shorter than aikido performers (M=389.1 ms; SD=38.4 ms), physical education students (M=398.6 ms; SD=40.9 ms), judo performers (M=400.3 ms; SD=27.7 ms), and wrestlers (M=497.6 ms; SD=20.9 ms).

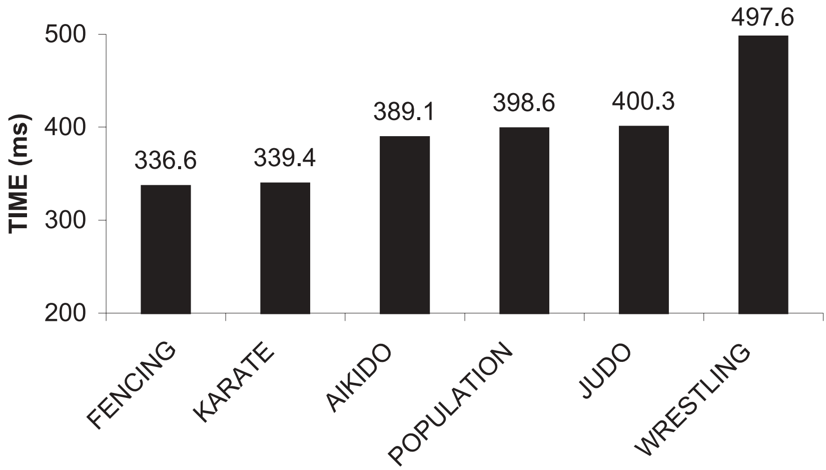

Figure 1: Multi choice reaction time of karate performers in comparison with athletes of other martial arts

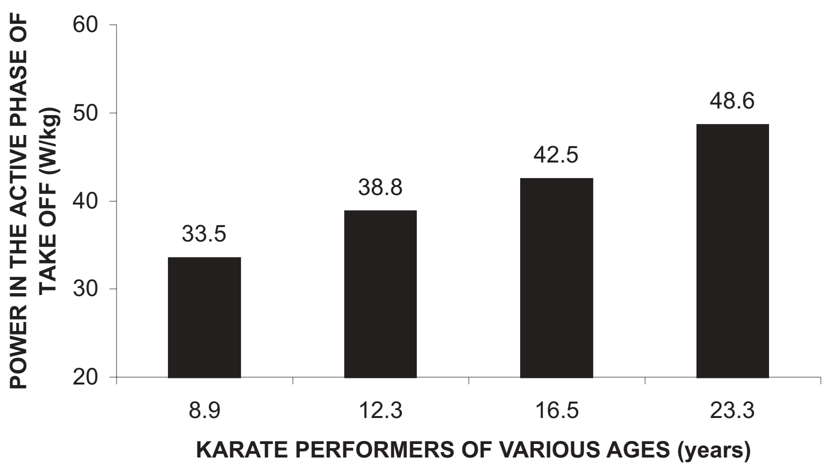

Figure 2: Power in the active phase of take off in 10-second test on the jump ergometer in karate performers of various ages

The power in the active phase of take off in ten-second test on the jump ergometer (see Figure 2) was higher in adults (M=48.6 $W.kg^{-1}$; SD=4.8 $W.kg^{-1}$) than in youth (M=42.5 $W.kg^{-1}$; SD=5.5 $W.kg^{-1}$), children of mean age 12.3 years (M=38.8 $W.kg^{-1}$; SD=6.5 $W.kg^{-1}$), and children of mean age 8.9 years (M=33.5 $W.kg^{-1}$; SD=4.3 $W.kg^{-1}$). In sixty-second load on the jump ergometer (see Figure 3) better endurance in explosive power of lower extremities was found in seniors (P_{akt} max 34.4 and min 32.2 $W.kg^{-1}$, respectively) than in youth (25.9 and 20.1 $W.kg^{-1}$, respectively) (Dzurenková, Zemková, & Longa, 1997; Zemková, Dzurenková, & Longa, 2000).

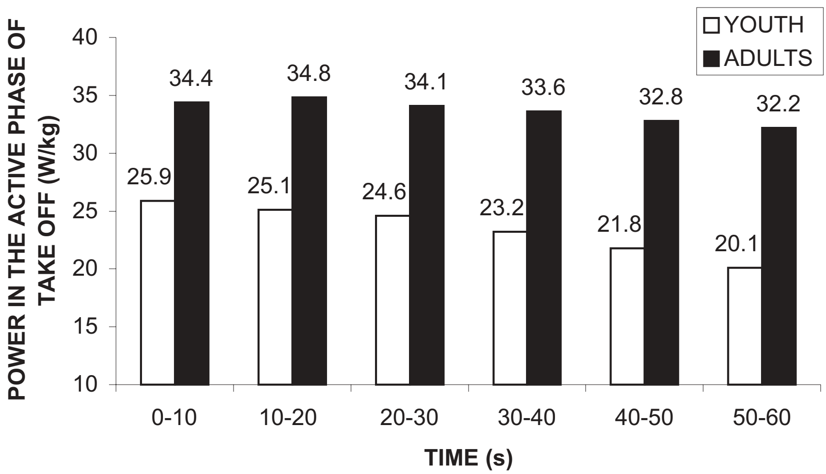

Figure 3: Power in the active phase of take off in 60-second test on the jump ergometer in youth and adult karate athletes

The results of 10-second loads on the isokinetic cycle ergometer at various revolution rates showed better ($p < 0.01$) strength of lower extremities at higher revolution rates at or from more than 110 per minute in adults (maximal power M=11.1 $W.kg^{-1}$; SD=1.1 $W.kg^{-1}$ at the revolution rates 110 rpm) than in youth (maximal power M=9.9 $W.kg^{-1}$; SD=0.9 $W.kg^{-1}$ at the revolution rates 100 rpm) (see Figure 4) and at or from 100 per minute in karate athletes of high performance level (maximal power 10.8 $W.kg^{-1}$ at the revolution rates 110 rpm) than those with lower karate performance (maximal power 8.7 $W.kg^{-1}$ at the revolution rates 100 rpm) (see Figure 5). Four years of karate training led to a significant improvement ($p < 0.01$) of power during the second and third year of training from 10.2 $W.kg^{-1}$ to 11.3 $W.kg^{-1}$ at the revolution rates of 120 rpm, from 10.2 $W.kg^{-1}$ to 11.6 $W.kg^{-1}$ at the revolution rates of 130 rpm, from 9.8 $W.kg^{-1}$ to 11.6 $W.kg^{-1}$ at the revolution rates of 140 rpm and during the third and fourth years of training resulted in significant ($p < 0.05$) increase of power from 11.3 $W.kg^{-1}$ to 12.1 $W.kg^{-1}$ at the revolution rates of 120 rpm, from 11.6 $W.kg^{-1}$ to 12.2 $W.kg^{-1}$ at the revolution rates of 130 rpm, and from 11.6 $W.kg^{-1}$ to 12.3 $W.kg^{-1}$ at the revolution rates of 140 rpm (see Figure 6). Also a six-week training focusing on the development of strength abilities showed a significant improvement of power from 9.6 $W.kg^{-1}$ to 10.4 $W.kg^{-1}$ at the revolution rates of 100 rpm ($p < 0.05$), from 9.5 $W.kg^{-1}$ to 11.2 $W.kg^{-1}$ at the revolution rates of 110 rpm, from 9.9 W.kg^{-1} to 11.3 at the revolution rates of 120 rpm and from 9.8 W.kg^{-1} to 11.6 W.kg^{-1} at the revolution rates of 140 rpm ($p < 0.01$) (Figure 7) (Dzurenková & Zemková, 1999).

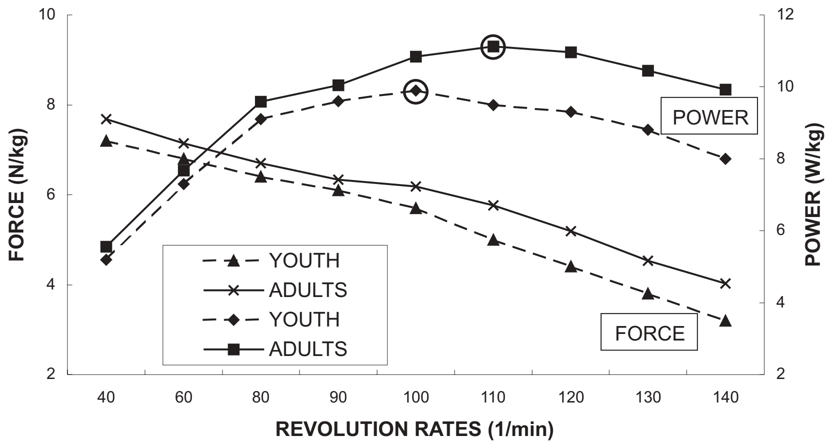

Figure 4: Power and force at the revolution rates from 40 to 140 rpm measured on the isokinetic cycle ergometer in youth and adult karate athletes

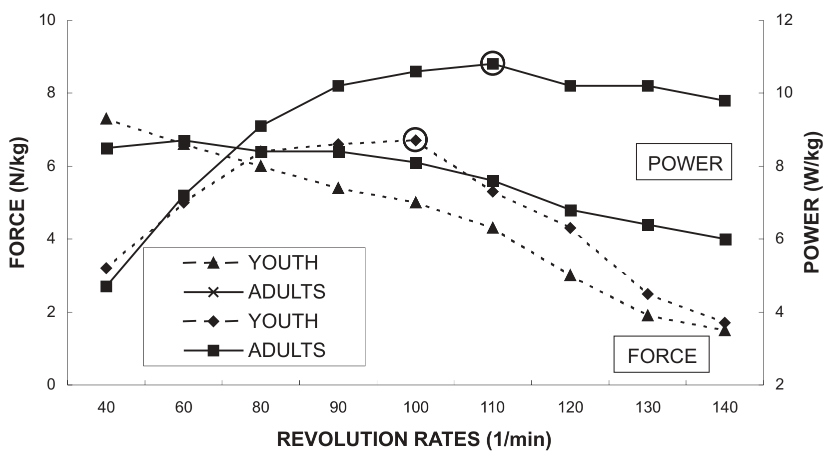

Figure 5: Power and force at the revolution rates from 40 to 140 rpm measured on the isokinetic cycle ergometer in two karate athletes of different performance level

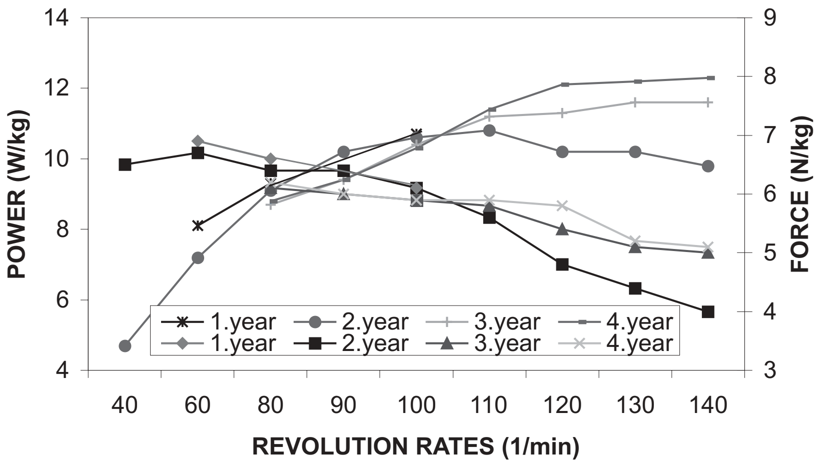

Figure 6: Power and force at the revolution rates from 40 to 140 rpm measured on the isokinetic cycle ergometer during four years of karate training

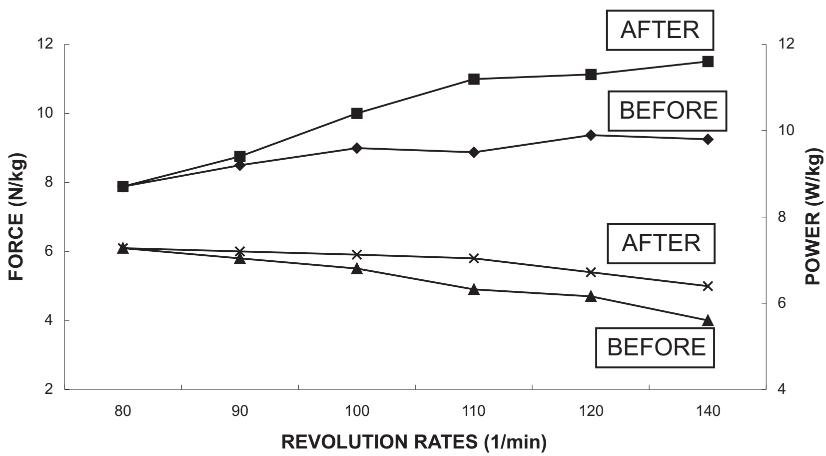

Figure 7: Power and force at the revolution rates from 80 to 140 rpm measured on the isokinetic cycle ergometer prior to and after six weeks of karate training

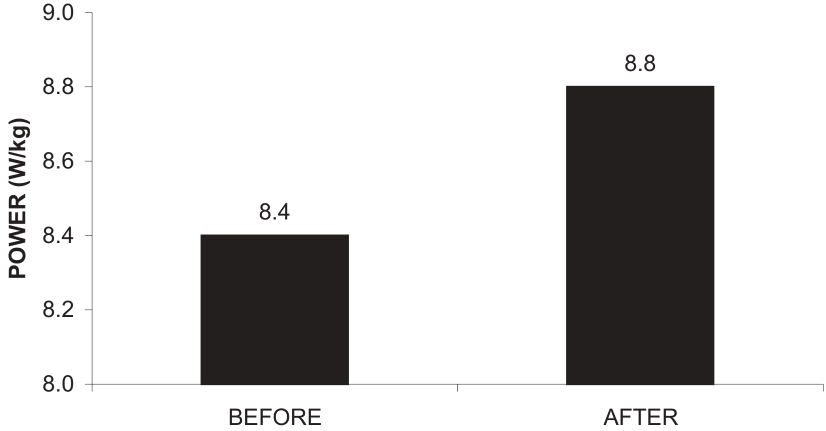

Figure 8: Power achieved in 30-second "all-out" load on the isokinetic cycle ergometer prior to and after four weeks of karate training

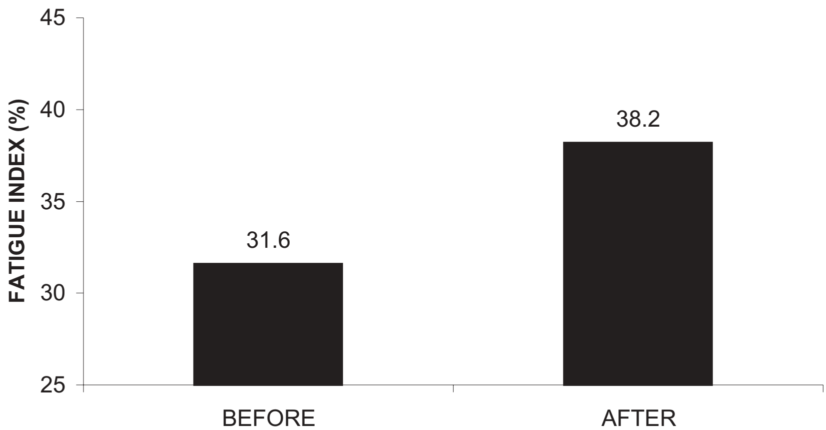

Fig. 9 Fatigue index in 30-second "all-out" load on the isokinetic cycle ergometer prior to and after four weeks of karate training

The results of 30-second "all-out" load on the cycle ergometer after four weeks of training showed no significant differences in power (M=8.4 $W.kg^{-1}$; SD=1.1 and M=8.8 $W.kg^{-1}$; SD=0.6 $W.kg^{-1}$, respectively) (see Figure 8) and fatigue index (31.6 and 38.2 %, respectively) (see Figure 9) (Dzurenková, Zemková, & Longa, 2000). Similarly, in 30-second "all-out" tethered running on the treadmill there were no significant differences in drag power produced in the initial (from 574.3 to 611.8 W) and final 5-second period (from 434.7 to 457.1 W) at the velocity of 10 $km.h^{-1}$ (see Figure 10). In addition, in the initial period at the velocity of 18 $km.h^{-1}$ no differences were recorded (from 587.3 to 582.8 W), however, in the final 5-second period the values were significantly ($p < 0.05$) higher (from 346.1 to 389.1 W) (see Figure 11). The fatigue index was therefore similar at the velocity of 10 $km.h^{-1}$ (24.0 and 24.7 %, respectively), but lower at the velocity of 18 km.h^{-1} (40.6 and 33.2 %, respectively) (see Figure 12) (Zemková, Hamar, & Schickhofer, 1999).

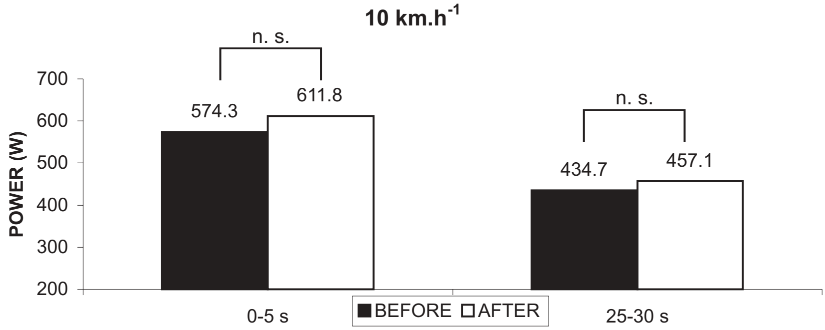

Figure 10: Power in the initial and final period of 30-second "all-out" tethered running on the treadmill at the velocity of 10 km.h^{-1} prior to and after four weeks of training in karate

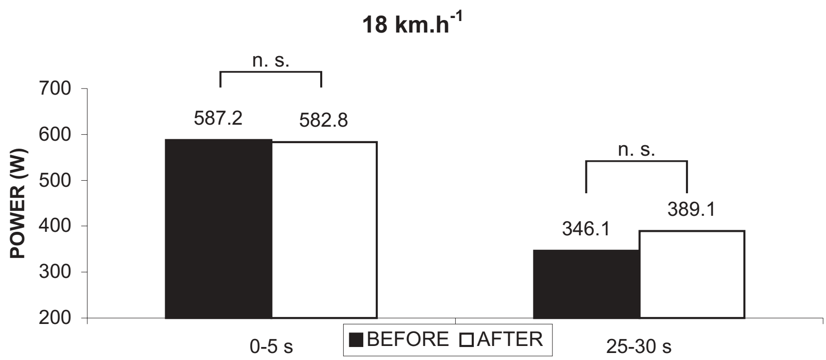

Figure 11: Power in the initial and final period of 30-second "all-out" tethered running on the treadmill at the velocity of 18 km.h^{-1} prior to and after four weeks of training in karate

Aerobic capacity examined by means of spiroergometry showed (see Figure 13) in children of mean age 8.9 years VO_2max.kg^{-1} M=47.8 ml.kg^{-1}; SD=8.6 ml.kg^{-1}, oxygen pulse M=8.6 ml; SD=2.0 ml, in children of mean age 12.3 years VO_2max.kg^{-1} M=50.2 ml.kg^{-1}; SD=3.8 ml.kg^{-1}, oxygen pulse M=10.8 ml; SD=1.5 ml (Zemková, Dzurenková, & Longa, 2000), in youth VO_2max.kg^{-1} 46.8 ± 10.3 ml.kg^{-1}, oxygen pulse 14.2 ± 3.8 ml, and in adults VO_2max.kg^{-1} 44.4 ± 5.5 ml.kg^{-1}, oxygen pulse 17.9 ± 1.9 ml (Zemková & Dzurenková, 2001).

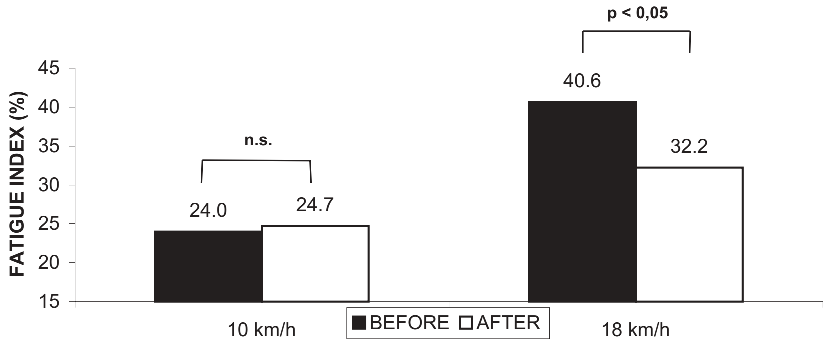

Figure 12: Fatigue index in 30-second "all-out" tethered running on the treadmill at the velocity of 10 and 18 km.h^{-1}, prior to and after four weeks of training in karate respectively

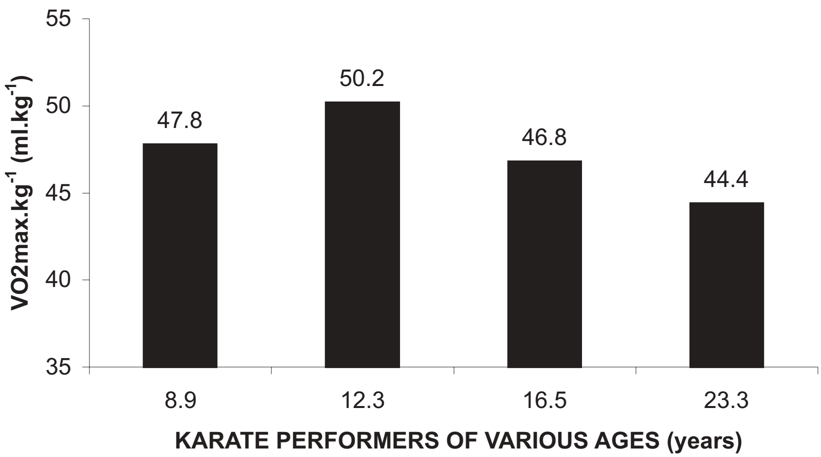

Figure 13: VO_2max in karate performers of various ages.

DISCUSSION

It is known that multi choice reaction time, explosive power, strength, and anaerobic abilities are the most important characteristics to be measured in karate. Results showed that karate athletes achieved better reaction time in agility test than athletes of other martial arts.

Originality and specificity of this test do not allow comparison of these results with those obtained in other studies. However, some of them have documented changes induced by karate training in the choice reaction time task (videotaped scenes of opponent's offensive actions, which simulated the athletes' view in real situations), but any in simple reaction time (Mori, Ohtani, & Imanaka, 2002), suggesting that such an ability is closer to the one used during training or competition. In this case also the anticipatory skills of karate athletes regarding the target area of an opponent's attack have to be taken in account, since these have been shown to be better in experienced karate athletes compared to novices.

Regarding the endurance in explosive power of lower extremities assessed by a method of repeated vertical jumps in duration of 60 seconds this ability has been found to be better in seniors than in youth. In comparison with population (Hamar & Tkáč, 1995), the power in the active phase of take off achieved in 10-second test on jump ergometer was higher in both groups examined. This ability is together with the acceleration of primary importance in karate athletes characterized by fast execution of various techniques with the whole body quickly moving through space, either vertically as in jumping kicks, or horizontally as in stepping in punches (Imamura, Yoshitaka, Uchida, Nishimura, & Nakazawa, 1998). The 10-second test on the isokinetic cycle ergometer was applied to assess the strength of lower extremities. By such method long- and short-term karate training has been shown to improve power at higher revolution rates.

Similarly, a significant increase in dynamic strength evaluated by speed of an unloaded movement (a karate punch), however not in maximal muscle strength following sixteen weeks of karate and resistance training, was observed in the study of Voigt and Klausen (1990), indicating that these changes reflect specificity of the karate training. This ability is therefore better in highly competitive than in novice karate athletes as shown by Imamura and colleagues (1998).

Nevertheless, to reveal specific changes induced by the preferred form of exercise in karate the testing methods have to be very close to those used during such training. Changes in anaerobic capabilities measured by means of 30-second tests on the isokinetic cycle ergometer and in the form of tethered running on the treadmill were related to subjects' actual ranking. Though both methods enable the evaluation of strength abilities, for karate athletes pedalling does not really provide a specific form of muscle activity. Based on the results obtained a 30-second "all-out" tethered running on the treadmill seems to be more appropriate alternative. In addition to these abilities, endurance is necessary to prevent fatigue during intense karate training. Aerobic capacity of karate athletes of various ages evaluated by means of spiroergometry showed good aerobic abilities in comparison with population (Seliger & Bartunek, 1976).

Values of oxygen uptake obtained in the present study are comparable with the results obtained by several authors who documented VO_{2max} measured on the cycle ergometer of M=45.5 $ml.kg^{-1}.min^{-1}$; SD=5.0 $ml.kg^{-1}.min^{-1}$ (Zehr & Sale, 1993), M=40.7 $ml.kg^{-1}.min^{-1}$; SD=6.7 $ml.kg^{-1}.min^{-1}$ (Chukwuemeka & Al-Hazzaa, 1992), or lower (M=36.8 $ml.kg^{-1}.min^{-1}$; SD=5.4 $ml.kg^{-1}.min^{-1}$) (Francescato, Talon, & Prampero, 1995). Higher values of M=57.5 $ml.kg^{-1}.min^{-1}$; SD=5.2 $ml.kg^{-1}.min^{-1}$ (Imamura, Yoshimura, Uchida, Tanaka, Nishimura, & Nakazawa, 1996), and M=57.3 $ml.kg^{-1}.min^{-1}$; SD=4.3 $ml.kg^{-1}.min^{-1}$ (Shaw & Deutsch, 1982) were achieved on the treadmill, which is know from literature (Astrand & Saltin, 1961). Slight differences in oxygen uptake of examined karate athletes may be ascribed to their performance level, training duration and intensity.

According to the authors these values are higher than in non-athletic persons and comparable to non-endurance athletes, such as rink cyclists, fencers, golfers, weight-lifters, handball and table tennis players (Joussellin, Handschuh, Barrault, & Rieu, 1984). Besides sparring (Funakoshi, 1973; Iiyama, 1973; Schmidt & Royer, 1973; Stricevic, Okazaki, Tanner, Mazzarella, & Merola, 1980; Šebej, 1985; Pieter, Taaffe, & Heijmans, 1990) advanced kata has also been proved to be an effective means for the enhancement of aerobic power and capacity (Zehr & Sale, 1993). Based on the results of the present study the functional assessment of karate athletes by employed computer based diagnostic systems may be considered suitable methods for the evaluation of karate performance.

Several years of experience with functional diagnostics of karate athletes showed that for the assessment of their sport performance various tests are appropriate, namely the agility test evaluating multi choice reaction time, ten and sixty-second tests on the jump ergometer evaluating explosive power of lower limbs and endurance, a thirty-second load on a treadmill in the form of tethered running evaluating anaerobic abilities, and a ten-second exercise bout on the isokinetic cycle ergometer evaluating the strength of lower limbs. In addition, spiroergometric examination may provide useful information concerning aerobic capabilities of these athletes.

These tests allow talent identification, differentiation of karate athletes of different ages and performance level, assessment of their actual training state and the effect of training focused on the improvement of specific capabilities of karate performance. Such information can contribute to more effective physical preparation and precise selection of children and adolescents for top level karate.

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