Maximal Oxygen Uptake, Body Composition and Strength of Highly Competitive and Novice Karate Practitioners

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Introduction

Karate is one of the most popular martial arts practiced both inside and outside of Japan. Traditional karate training involves basics, kata and sparring. 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 are set forms in pre-established sequences of defensive and offensive techniques and movements. Movements in kata are very formal, systematic and sometimes very slow, in prescribed stances and directions. Sparring is the execution of defensive and offensive techniques while freely moving against an opponent. In addition to the traditional karate training, many competitive karate practitioners follow a strenuous running and weight training program to increase cardiovascular endurance, lean body mass, strength and power.

It has been noted that karate training in general and karate kata in particular have been claimed to contribute to increasing general physical fitness and/or cardiovascular fitness (Funakoshi, 1973; Iiyama, 1973; Zehr and Sale, 1993); however, only a few studies have investigated maximal oxygen uptake (VO₂max) and/or body composition of karate practitioners (Chukwuemeka and Al-Hazzaa, 1992; Francescato, 1995; Shaw and Deutsch, 1982; Zehr and Sale, 1993). Furthermore, none of the studies reported above have addressed the physical characteristics of highly competitive karate practitioners. The purpose of this study was to investigate VO₂max, body composition and strength of highly competitive karate practitioners and compare them to less experienced or novice karate practitioners.

Methods

Subjects

Seven highly competitive black belt male practitioners (HCBB Group) and 9 novice white belt male practitioners (NWB Group) who were members of the Fukuoka University Karate Club participated in this study. Of the HCBB Group, 2 subjects were former world champions and the other 5 were prize winners in international competitions in sparring. The NWB Group started karate when they entered the university. Karate was the only current form of training for at least 5 years for the HCBB Group and for 8 months for the NWB Group. The study protocol was approved by the Ethics Committee of Nakamura Gakuen University and informed consent was obtained from each subject prior to their participation in this study.

During the school days, the university karate team usually practiced for about one hour in the morning and 3 to 4 hours in the evening Monday through Friday. The team also practiced for about 3 to 4 hours on Saturday mornings. The one hour morning practice primarily consisted of stretching and 30-40 minutes of running. The evening practice on Monday, Wednesday and Friday primarily consisted of a standard karate training (basics, kata and sparring) and a special training to speed-up sparring techniques. The evening practice on Tuesday and Thursday and the morning practice on Saturday primarily consisted of cross-training; karate and weight training. During the summer (for about one month) and spring (for about one and a half months) university vacations, the team practiced for about 2 hours, 5 evenings per week. At the end of each vacation, the team had about one week of very hard training in a camp like atmosphere.

Skinfold measurements

The triceps and subscapular skinfold thicknesses
were measured with a Harpenden caliper on the right side of the body with the subject in a standing position. The average of 3 measurements at each site was used to calculate the body density (Nagamine and Suzuki, 1964) and percent body fat (%Fat) (Brozek et al., 1963).

Maximal treadmill exercise test
Each subject performed an incremental test to volitional exhaustion on a Woodway treadmill using a modified Bruce Protocol which consisted of 3-minute work stages, starting with 1.7 mph and 0% grade, after which the treadmill speed and grade were increased according to the protocol of Bruce et al. (Bruce, 1973). The test was conducted in air-conditioned facilities with a temperature set at 20 °C. After sitting comfortably for 5–10 min, resting blood lactate levels were determined for each subject. The peak values were also determined immediately after finishing the treadmill test. Shortly after 25 μl of blood was drawn from an earlobe, it was analyzed with the YSI MODEL 23L LACTATE ANALYZER which was calibrated with a 5.0 mmol·l⁻¹ lactate standard (YSI 2327 STANDARD) between each reading. Ventilatory measurements were made by standard open-circuit calorimetry (WYVERN SOFTWARE PHYSIOLOGIC EXERCISE TESTING SYSTEM, P.K. Morgan Instruments, Inc) with 30 second sampling intervals. Subjects wore noseclips and breathed through a Hans Rudolph low-resistance low-dead-space valve that was connected to a mixing chamber via lightweight tubing. The system was calibrated against a known mixture of gases (Sumitomo Seika, Chiba, Japan) before each experiment. The electrocardiogram (ECG), using a bipolar CM₅ lead configuration, was monitored with a radio telemetry (NIHON KODEN). Exercise heart rate in beats·min⁻¹ was determined during the final minute of each stage.

Strength assessments
The subjects were allowed to stretch for a few minutes, after which bench press and half squat strength were assessed using the one-repetition maximum (1-RM) technique. A successful performance was defined as lifting barbells from the chest for bench press and from the position in which the thighs are parallel to the floor for half squat. Subjects lifted increasingly heavier weights until reaching a weight they were unable to raise. The last successfully lifted weight was taken as the 1-RM. Subjects were given strong verbal encouragement.

Statistical analysis
Descriptive statistics included means and standard deviations (SD). Due to the small number of subjects in each group, differences between the 2 groups were analyzed by using the Mann-Whitney U test which is a nonparametric test. The nonparametric methods are based on less restricting assumptions than those underlying parametric ones concerning the shape of the distribution of the characteristic being measured (Spence et al., 1976). A p value of less than 0.05 was considered to be statistically significant.

Results
The characteristics of the subjects are shown in Table 1. The HCBB Group showed significantly higher mean values in age, karate experience, lean body mass, bench press and half squat strength and maximal ventilation volume relative to the NWB Group. There were no significant differences between the 2 groups in the body height and weight, %Fat, fat mass, VO₂max in ml·min⁻¹ and in ml·kg⁻¹·min⁻¹, peak blood lactate and HRmax.

Discussion
There are a limited number of studies investigating the VO₂max and body composition of karate practitioners (Chukwuemeka and Al-Hazaa, 1992; Francescato et al., 1995; Shaw and Deutsch, 1982; Zehr and Sale, 1993). It is our belief that this study is the first to present such data for highly competitive karate practitioners. The HCBB Group had significantly longer karate experience than the NWB Group, which may indicate that experience and time commitment for development of specific motor skills required in karate is important.

<table>
<thead>
<tr>
<th>Table 1 Characteristics of subjects</th>
<th>HCBB Group (n=7)</th>
<th>NWB Group (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>21.3 (0.8)</td>
<td>19.9 (0.8)**</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>172.9 (7.3)</td>
<td>169.5 (4.3)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>66.3 (8.2)</td>
<td>60.1 (6.9)</td>
</tr>
<tr>
<td>Experience (years)</td>
<td>12.6 (3.4)</td>
<td>1.2 (0.5)*****</td>
</tr>
<tr>
<td>%Fat</td>
<td>10.7 (2.0)</td>
<td>12.6 (4.5)</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>7.2 (2.3)</td>
<td>7.7 (3.8)</td>
</tr>
<tr>
<td>LBM (kg)</td>
<td>59.1 (6.1)</td>
<td>52.3 (4.1)*</td>
</tr>
<tr>
<td>Bench Press Strength (kg)</td>
<td>87.1 (12.5)</td>
<td>74.4 (7.3)*</td>
</tr>
<tr>
<td>Half Squat Strength (kg)</td>
<td>137.5 (12.6)</td>
<td>120.0 (13.2)*</td>
</tr>
<tr>
<td>VO₂max (ml·min⁻¹)</td>
<td>3813 (468)</td>
<td>3438 (298)</td>
</tr>
<tr>
<td>VO₂max (ml·kg⁻¹·min⁻¹)</td>
<td>57.5 (5.2)</td>
<td>57.2 (4.9)</td>
</tr>
<tr>
<td>Peak LA (mmol·l⁻¹)</td>
<td>9.0 (1.3)</td>
<td>9.1 (2.6)</td>
</tr>
<tr>
<td>HRmax (beats·min⁻¹)</td>
<td>193.4 (9.3)</td>
<td>197.0 (11.7)</td>
</tr>
<tr>
<td>VEmax (l·min⁻¹)</td>
<td>129.4 (17.0)</td>
<td>114.2 (10.0)*</td>
</tr>
</tbody>
</table>

Values are mean (SD). *P<0.05, **P<0.01, ***P<0.001. Abbreviations: HCBB Group=highly competitive black belt group; NWB Group=novice white belt group; %Fat=percent body fat; LBM=lean body mass; VO₂max=maximal oxygen uptake; LA=lactic acid; HRmax=maximal heart rate; VEmax=maximal ventilation.
in the mean VO\textsubscript{2max} in ml\cdot min\textsuperscript{-1} and in ml\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1}, HR\textsubscript{max} and peak blood lactate measured by the treadmill run. Shaw and Deutsch (1982) reported comparable mean VO\textsubscript{2max} (57.3 ± 4.3 ml\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1}) and HR\textsubscript{max} (196.6 ± 4.8 beats\cdot min\textsuperscript{-1}) measured by treadmill run for the subjects with karate experience of 4 months to 10 years. On the other hand, Zehr and Sale (1993) reported lower mean VO\textsubscript{2max} (45.5 ± 5.0 ml\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1}), HR\textsubscript{max} (170.8 ± 12.7 beats\cdot min\textsuperscript{-1}) and peak blood lactate (6.65 ± 1.07 mmol\cdot l\textsuperscript{-1}) and slightly higher mean maximal ventilation volume (132.5 ± 20.8 l\cdot min\textsuperscript{-1}) measured by the bicycle ergometer for highly skilled karate practitioners. Francescato et al. (1995) found a much lower mean VO\textsubscript{2max} measured by the bicycle ergometer for subjects with one to 3 years of experience (36.8 ± 5.4 ml\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1}). Chukwuemeka and Al-Hazzaa (1992) also indicated a lower VO\textsubscript{2max} for Saudi national judo-karate athletes (40.7 ± 6.7 ml\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1}). However, the data for the judo and karate practitioners were not shown separately. From this review, it is difficult to interpret how representative the results are for Saudi national karate practitioners. Although these subjects were members of the Saudi national karate team, they were not highly competitive in the world competition or other international competitions.

These disparities in findings may reflect differences in the mode of exercise test. It is well known that the treadmill test yields higher values in VO\textsubscript{2max} as opposed to bicycle test (Åstrand and Saltin, 1961). Another point which should also be taken into consideration when discussing the disparities in the study results is the quantity of karate training. The subjects in the study by Francescato et al. (1995) had practiced karate for the past one to 3 years and trained at least twice a week for 2 hours. Other studies (Chukwuemeka and Al-Hazzaa, 1992; Shaw and Deutsch, 1982; Zehr and Sale, 1993) did not report the quantity of their karate training.

For our study group karate was the only current form of training at least for 5 years in the HCBB Group and for 8 months in the NWB Group. Both groups practiced the same training routines which consisted of 30-40 minutes of running 5 mornings per week and 3 to 4 hours of karate exercises 6 times per week as described in the methods. It was found that 8 months of such intense karate training may possibly be enough for beginners to elicit similar VO\textsubscript{2max} relative to the highly competitive karate practitioners.

In comparison with top level athletes in various sports (Joussellin et al., 1984), the VO\textsubscript{2max} in ml\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1} in the HCBB and NWB Groups were much lower than long and middle distance runners, were comparable to rink cyclists, fencers, golfers, weight-lifters, hand-ball and table tennis players and were higher than sprinters and volley-ball players. Our findings indicate that the mean VO\textsubscript{2max} in ml\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1} in both groups were in the range of non-endurance athletes. Due to the fact that karate practices are characterized by short spells of high intensity exercises and interrupted by milder periods such as active standing rest, karate training itself appears to be anaerobic. Although karate practitioners seems to be non-endurance athletes, their mean VO\textsubscript{2max} in ml\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1} were approximately 19% higher than the values for non-athletic men of similar age as determined by the Laboratory of Physical Education, Tokyo Metropolitan University (1989). This level of aerobic capacity might be necessary to prevent fatigue during intense karate training.

There were no significant differences between the HCBB and NWB Groups in the mean %Fat. Their mean %Fat were slightly lower than the values for karate practitioners reported in the two other studies (Francescato et al., 1995; Shaw and Deutsch, 1982) and were lower than the value (14.0 ± 4.2%) reported for the sedentary men of similar age (Takami et al., 1993). This contrasts with the mean values of lean body mass, bench press and half squat strength for the HCBB Group which were significantly higher than those for the NWB Group. Karate practitioners are characterized by quick 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. While momentum (mass times acceleration) is of primary importance to the karate practitioners, there is a high negative correlation between %Fat and performance in these activities where the body mass must be moved through space (Wilmore, 1983). Thus, if speed can be maintained, a large lean body mass with low %Fat is of considerable advantage in karate. In view of the fact that the HCBB Group consists of 2 former world champions and 5 other prize winners in international competitions, our findings indicate that of the variables examined in the present study, lean body mass, bench press and half squat strength are indicative of highly competitive karate practitioners.

In conclusion, the results of this study indicate that novice and highly competitive collegiate karate practitioners are within the range of non-endurance athletes in aerobic capacity. Their %Fat values were lower relative to the normal college-age population. Furthermore, of the variables examined in the present study, lean body mass, bench press and half squat strength distinguished the highly competitive karate practitioners from the novice karate practitioners.

References


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