Introduction

Although many women engage in karate training (Atkinson, 1983), our understanding of metabolic demands of karate training is mostly confined to men because most karate studies used male subjects (Imamura et al., 1997; Imamura et al., 1999; Pieter et al., 1990; Schmidt and Royer, 1973; Stricevic et al., 1980; Zehr and Sale, 1993), whereas some studies that were found included female subjects (Gardecki et al., 1994; Shaw and Deutsch, 1982; The Scientific Research Group of the Committee on Improving Competitive Ability, Federation of All Japan Karate-Do Organizations, 1997 and 1998). In a previous study using male subjects (Imamura et al., 1997), we reported that heart rate (HR) responses during performing 1,000 punches and 1,000 kicks were moderate. The purpose of this study was to investigate oxygen uptake (V˙O₂), HR and blood lactate responses and rate of perceived exertion (RPE) during 1,000 punches and 1,000 kicks in female black belt karate practitioners.

Methods

Six female black belt practitioners who were members of the N and F University Karate Clubs participated in this study. The mean (±SD) age, body height, weight and karate experience of the subjects were 19.5±0.5 yrs, 160.6±2.6 cm, 54.5±5.1 kg and 5.1±4.5 yrs, respectively.

The details of experimental procedure and methods of measurements have been reported in the previous studies (Imamura et al., 1997, 1999 and 2002). Briefly, 3 to 7 days before the experiment started each subject performed an incremental test to volitional exhaustion on a Woodway treadmill (Sakai, Tokyo, Japan) using a modified Bruce Protocol (American College of Sports Medicine; ACSM, 1995). After the subjects sat comfortably for 5–10 min, resting blood lactate levels were determined. The peak values were also determined immediately after they finished the treadmill test. Shortly after the 5 μl of blood was drawn from an earlobe, it was analyzed with the Lactate Pro Analyzer (Akray, Tokyo, Japan). Ventilatory measurements were made by standard open-circuit calorimetry (Wyvern Software Physiologic Exercise Testing System, P.K. Morgan Instruments, Inc., Rainham, UK) with 30-sec sampling intervals. The system was calibrated against a known mixture of gases before each experiment. The ECG, using a bipolar CM5 lead configuration, was monitored via radio telemetry (Nihon Koden, Tokyo, Japan). Exercise HR was determined during the final min of each stage.

The subjects were allowed to stretch for a few mins, after which they performed 1,000 punches and 1,000 kicks with alternating arms and legs in the parallel stance in which the feet were shoulder width apart. The subjects performed one technique every sec, so that it took 16 min and 40 sec to finish 1,000 punches or 1,000 kicks. Thirty min sitting rest was taken between the performances of 1,000 punches and 1,000 kicks.

Blood lactate samples were taken in a sitting position in a chair as described above at the end of the rest period before exercise, and immediately after the performance of 1,000
punches and 1,000 kicks. The ECG as described above was monitored with a 4-channel radio telemetry (Fukuda Denshi, Tokyo, Japan). The subjects’ HR was recorded for 10 sec at the end of the 10-min sitting rest and every min thereafter. Expired gas was collected by the Douglas bag method for the last 5 min of the rest period before exercise. During performing 1,000 punches and 1,000 kicks, it was collected for one min at the 5th, 10th, and the last min. The volume of gas was measured in a wet gas meter (Sinagawa Corp., Tokyo, Japan). Analyses for O₂ and CO₂ were performed on the system as described above. RPE using Borg’s scale (Borg, 1973) was recorded immediately after performing 1,000 punches and 1,000 kicks.

Descriptive statistics included means and SD. All data were analyzed by an ANOVA with repeated measures and subsequent Scheffe test for post-hoc analysis. A P value of less than 0.05 was considered to be statistically significant.

Results

The mean (±SD) VO₂max in ml·min⁻¹ and in ml·kg⁻¹·min⁻¹, HRmax, and peak blood lactate of the subjects were 2335±408 ml·min⁻¹, 42.7±5.1 ml·kg⁻¹·min⁻¹, 189.5±8.6 beats·min⁻¹, 10.1±1.2 mmol·l⁻¹, respectively.

The responses of VO₂ and %VO₂max, HR, and %HRmax, during the performance of 1,000 punches and 1,000 kicks are shown in Fig. 1. Their respective mean values for 1,000 punches were 406±39 ml·min⁻¹, 17.1±4.1%, 108.2±13.0 beats·min⁻¹, and 57.1±6.2%, respectively and for 1,000 kicks were 941±173 ml·min⁻¹, 41.1±8.8%, 156.6±12.0 beats·min⁻¹, and 82.7±5.8%, respectively.

The mean RPE and blood lactate responses immediately after performing 1,000 punches were 11.3±0.8 and 1.0±0.4 mmol·l⁻¹ and after 1,000 kicks were 15.7±1.0 and 3.0±0.9 mmol·l⁻¹, respectively.

Discussion

In the previous study (Imamura et al., 1997) using male highly skilled (BB Group) and novice (WB Group) karate practitioners, we reported that the mean HR and %HRmax during 1,000 punches for the BB Group were 102.5±14.8 beats·min⁻¹ and 53.1±8.5%, respectively, and for the WB Group were 116.1±17.9 beats·min⁻¹ and 58.1±7.7%, respectively. Likewise, the mean values in 1,000 kicks for the BB Group were 127.4±12.4 beats·min⁻¹ and 66.0±8.0%, respectively, and for the WB Group were 137.0±14.4 beats·min⁻¹ and 70.1±7.4%, respectively. In the present study, the mean HR and %HRmax for 1,000 punches were comparable to those respective mean values in the previous study (Imamura et al., 1997). However, their respective mean values for 1,000 kicks (156.6±12.0 beats·min⁻¹ and 82.7±5.8%, respectively) were higher than the respective values obtained in the previous study. These differences could be due to the fact that women have less muscle than men (Brooks et al., 1996), and/or the lower VO₂max of the subjects in the present study (42.7±5.1 ml·kg⁻¹·min⁻¹) as opposed to the mean values of 59.0±6.6 ml·kg⁻¹·min⁻¹ for the BB Group and 57.5±5.2 ml·kg⁻¹·min⁻¹ for the WB Group in the previous study. More physically fit or athletically trained individuals have a lower HR for a given submaximal workload (deVries, 1980).

As we noted in the previous study employing men (Imamura et al., 1999) and women (Imamura et al., 2002), higher HR responses were elicited during the 5 types of karate exercises.
studied for given %$\dot{V}O_2_{\text{max}}$ than during the treadmill run. Shaw and Deutsch (1982) noted that these could be due to the static nature of the arm movements involved in these activities, the arm movements themselves, and/or the combined effects of these types of exercises performed by the arms. Upper-body exercise has been shown to induce a greater HR at a given $\dot{V}O_2$ than lower body exercises (Gutin et al., 1988; Toner et al., 1990). The higher circulatory load in upper-body exercise results from the use of a smaller muscle mass, increased intrathoracic pressure, and a less effective muscle pump, which decrease venous return of blood to the heart (Brooks et al., 1996). In the present study, however, higher HR was elicited not only during 1,000 punches, but also during 1,000 kicks. Thus, the static nature of the leg movements during 1,000 kicks may also elicit higher HR responses. In addition, the elevation of sympathetic activity may also elicit higher HR responses. Sympathetic activity activates secretion of epinephrine and norepinephrine from the adrenal medulla. Both hormones increase HR (Brooks et al., 1996).

In the previous study (Imamura et al., 1997), the mean RPE immediately after performing 1,000 punches for the BB and WB Groups were 12.2 ± 1.2 and 12.8 ± 1.2, respectively. The result of the present study (11.3 ± 0.8) was comparable to those results in the previous study, which corresponds to a perception of effort as light (ACSM, 1998). The mean RPE immediately after performing 1,000 kicks for the BB and WB Groups obtained in the previous study and in the present study were 14.2 ± 1.2, 16.7 ± 1.7 and 15.7 ± 1.0, which corresponds to a perception of effort as hard (ACSM, 1998).

The mean blood lactate responses immediately after performing 1,000 punches in the present study (1.0 ± 0.4 mmol·L$^{-1}$) was comparable to those results for the BB and WB Groups in the previous study (Imamura et al., 1997). Although the mean blood lactate responses immediately after performing 1,000 kicks in the present study (3.0 ± 0.9 mmol·L$^{-1}$) was slightly higher than the values reported for the BB and WB Groups (1.3 ± 0.4 and 2.4 ± 0.8 mmol·L$^{-1}$, respectively), the value was still moderate. Because these exercises were continuous, and blood lactate samples were taken immediately after performing 1,000 punches and 1,000 kicks, the modest elevation in blood lactate may possibly be the result of the blood lactate produced by an active muscle group taken up and utilized by an inactive muscle (Brooks, 1991).

In conclusion, $\dot{V}O_2$, HR and blood lactate responses and RPE during 1,000 punches and 1,000 kicks were moderate in the female black belt karate practitioners.

References


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Received: September 17, 2002
Accepted: January 10, 2003
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