HEART RATE RESPONSE DURING A KARATE TRAINING SESSION

EXERCISE AND SPORTS SCIENCES

ORIGINAL ARTICLE

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ABSTRACT

Karate practice can promote beneficial adaptations on the health-related components of physical fitness. Among the components, the maximum oxygen uptake ($\dot{V}O_{2max}$) is an important indicator of cardiorespiratory fitness, as it is also a strong and independent predictor of the risk of death from cardiovascular disease and all other causes. Previous studies have evaluated the heart rate (HR) responses in the karate modality during protocols elaborated by researchers who simulated training. However, the results should be carefully interpreted, since elaborated protocols can compromise the ecological validity of the HR behavior. Thus, the aim of the study was to monitor the HR to investigate the distribution of intensity during a karate training session (TS) with ecological validity preserved. Nine athletes (M (SD) = 22 (5.2) years; 60.3 (12.9) weight; 170.0 (0.10) height; 170.0 (0.10) cm; 11.6 (5.7) % fat) performed a maximal incremental test (IT) and one TS with continuous HR monitoring, subsequently distributed by Edward´s method. The mean TS duration was 91.3 (11.9) min (IC95% = 82.0 – 100.5). The values of average and maximum HR of the TS were equivalent to 72 % (IC95% = 66 – 78 %) and 94 % (IC95% = 89 – 99 %) respectively, of maximum HR reached in the incremental test (HRmax). During 79.9 % (IC95% = 65.7 – 94.1 %) of the total time of TS the athletes remained at intensity above 60% of HRmax. Thus, it was concluded that the TS lies within the ACSM recommendations concerning intensity, duration and weekly frequency, presenting itself as an interesting alternative of exercise to promote cardiorespiratory fitness.

Keywords: oxygen consumption, martial arts, heart rate, health, physical fitness.

INTRODUCTION

Karate is one of the most popular martial arts practiced in the world[1]. The modality involves several muscular groups, with complex movements of rapid accelerations and disaccelerations[2]. The attack and defense short duration techniques are characterized by performance with maximum intensity, interrupted by small intervals[3] and make the modality comparable to an intermittent exercise[4].

Karate practice, as in other martial arts, promotes benefic adaptations on the physical fitness components related to health[5,6]. Among these components, the oxygen maximum consumption ($\dot{V}O_{2max}$) is an important indicator of cardiorespiratory fitness, as well as strong and independent predictor of risk of death by cardiovascular disease and all causes[7,8].

Light increase of $\dot{V}O_{2max}$ in the order of 1 MET (3.5ml.kg^{-1}.min^{-1}) is associated with decrease of 13% and 15% in risk of death by all causes and cardiac diseases, respectively[8]. Therefore, the physical exercise practice in its many different possibilities contributes to individual migration from the sedentary condition to physically active, and can promote satisfactory adaptations in the cardiorespiratory fitness[5,9,10] and consequent decrease in risk of death.

Thus, the American College of Sports Medicine[11] usually recommends continuous activities, such as running, cycling and swimming, in intensity zone between 60 and 90% of maximum heart rate (HR_{max}) for a period of time between 20 and 60 minutes, with weekly frequency between three and five times. However, some intermittent activities such as martial arts are not mentioned within the recommendations.

One of the widely used methods in the determination of intensityof training sessions is the heart rate (HR) monitoring[12] due to its relation with oxygen consumption ($\dot{V}O_2$). Having this method as starting point, it is possible to evaluate mean values, HR maximum or analyze the distribution of the training intensity by HR zones.

Previous studies evaluated the HR responses in the karate modality during protocols designed by researchers who simulated training[13-15]. Nevertheless, these results should be carefully interpreted, since protocols can compromise the ecological validity of the HR behavior. Consequently, the information about the HR response during one karate training session is limited.

Thus, the aim of this study was to investigate the intensity distribution during one karate training session with ecological validity preserved by the HR monitoring. We hypothesize that the intensity of a conventional karate session is different from the situations mentioned above and meets the ACMS recommendations[11] for development of cardiorespiratory fitness (60 to 90% ofHR_{max}).

METHODS

Subjects

The sample was composed of nine karate fighters of both sexes (M (SD) = 22 (5.2) years; 60.3 (12.9) kg; 170.0 (0.10) cm; 11.6 (5.7) % fat), namely five men (24.0 ± 6.4 years; 64.4 ± 15.6kg; 169.2 ± 9.4cm; 8.6 ± 5.5% fat) and four women (19.5 ± 2.1 years; 55.1 ± 7.7kg; 162.5 ± 3.5cm; 15.2 ± 3.6% fat), who regularly trained at least five times per week for at least two years. Al subjects were informed about the procedures to

be performed, the associated risks and benefits and in the sequence, they signed a Free and Clarified Consent Form approved by the Ethics in Local Research Committee, according to legal resolution 196/96 of the National Health Board, under the protocol number 192/07.

Experimental outlining

Initially, the athletes performed a protocol composed of evaluation of heart rate during a rest period (HR_r) with duration of five minutes and one maximum incremental test (T_{Imax}) on treadmill (Super ATL, Inbrasport, Brazil) for determination of the ventilator threshold (VT), respiratory compensation point (RCP), HR_{max} and $\dot{V}O_{2max}$. After a minimum 48-hour interval, they performed a training session, in which the HR was continuously monitored for subsequent analysis of the intensity distribution. All subjects were familiarized with the procedures and instruments and told not to perform intense efforts or ingest alcoholic drinks in the 24 hours preceding the tests, nor food and caffeinated drinks in the three hours preceding the test.

T_{Imax} for determination of VT, RCP, HR_{max} and $\dot{V}O_{2max}$

Initial velocities were 6 and 8km.h^{-1}for women and men, respectively. Inclination was set at 1% and increments of 1 km.h^{-1} were performed at every three minutes until voluntary exhaustion. During the entire progressive test HR was recorded in a cardiofrequency meter Polar® (S810i, Polar ElectoOy, Kempele, Finland), as well as the pulmonary gas exchanges at every 20 seconds in the gas analyzer $\dot{V}$O2000 (MedGraphics, USA). Calibration was performed before each test fromsample of room gas and known gas concentrations of O_2 (16%) and CO_2 (5%). The gas flow for the instrument was also calibrated with a three-liter syringe. The HR_{max} was considered as the mean of HR record of the last 30 seconds of progressive test. Criteria suggested in the literature were used for determination of the $\dot{V}O_{2max}$[16], VT and RCP values[17].

Conventional karate training session (TS)

During the TS, the athletes performed brief warm-up and stretching, non-standard and with approximate duration of 20 minutes. After the warm-up, the training session was separated in small shifts with duration of two minutes in which basic, combined and combined against an opponent techniques were performed. Small intervals with duration between 30 and 60 seconds were performed between the shifts for technique rotation, opponent or for rest, according to the daily training routine of the athletes. There was not interference from the researchers in the timetable and training adopted by the technical staff.

The cardiofrequency meter watch was strategically positioned on the back of the athlete, attached to the transmission tape inside the kimono to protect the apparatus and preserve the physical integrity of the athletes. The mean of the values recorded during the entire TS was defined as mean heart rate (HR_{tsmean}), while the highest value recorded during the TS was defined as maximum heart rate (HR_{TSmax}).

Training intensity distribution

The distribution of the training intensity was performed by the method proposed by Edwards[18], which consists of the division of the zones concerning the HR_{max} (Zone 1: 50 to 59% ofHR_{max}; Zone 2: 60 to 69% of HR_{max}; Zone 3: 70 to 79% of HR_{max}; Zone 4: 80 to 9% ofHR_{max}; Zone 5: 90 to 100% ofHR_{max}).

STATISTICS ANALYSIS

Initially, the Shapiro-Wilktest was used for analysis of the data distribution. Variables which presented normality were expressed in mean (M) and standard deviation (SD) values, in case it did not fulfill the concept of normality, in median, first and third quartiles. Sexes were compared with the Student's ttest for independent samples. Variance analysis of repeated measures was used for comparisons between distribution of time of TS, and in case of confirmed significance, the Bonferronipost hocwas applied when the involved variables in the comparison respected the parametric concepts. When these steps were not respected, the Friedman variance analysis and the Wilcoxontest as post hocwere used. The significance level adopted for all analyses was of 5%. Data were treated using the SPSS program for Windows, version 17.0.

RESULTS

The physiological characteristics of the karate fighters in mean (M) and standard deviation values (SD) are presented in table 1. The $\dot{V}O_{2max}$ mean of the group (n = 9; M (SD) = 47.1 (7.4) ml.kg^{-1}.min^{-1}; CI95% = 41.4-52.8) was considered high for both genders compared to the population standard[7]and with statistically significant difference between male and female athletes (table 1). Table 1 also presents the HR_r, HR_{max}, heart rate at ventilator threshold (HR_{VT}) and heart rate at respiratory compensation point (HR_{RCP}) values, with no statistical differences between genders.

There were not statistical differences either between male and female athletes for theHR_{tsmean} and HR_{TSmax} values obtained during the training session (table 2). The $HR_{tsmean}$and HR_{TSmax} values reached intensities equivalent to 72% (CI95% = 66-78%) and 94% (CI95% = 89-99%) of HR_{max}, respectively.

Table 1. Physiological characteristics of both sexes presented in values of mean and standard deviation values.

	Men (n = 5)	Women (n = 4)
HR_r (bpm)	62 (7)	69 (11)
HR_{max} (bpm)	198 (6)	194 (6)
HR_{VT}(bpm)	169 (7)	158 (8)
HR_{RCP}(bpm)	180 (8)	174 (6)
VO_{2max} (mL.kg^{-1}.min^{-1})	51.3 (6.0)	41.9 (5.5)*

(HR_r) Heart rate at rest; (HR_{max}) Maximum heart rate of the incremental test; (HR_{VT}) Heart rate in the ventilatory threshold; (HR_{RCP}) Heart rate in the respiratory compensation point.
* Difference of the male volunteers (P < 0.05).

Table 2. Individual responses of heart rate during the TS (n = 9).

Subjects	HR_{TSmed}	HR_{TSmax}	HR_{TSmed}	HR_{TSmax}
(n)	(Bpm)	(Bpm)	(Bpm)	(Bpm)
	Men		Women	
S1	138	182	---------	---------
S2	152	198	123	167
S3	126	168	146	183
S4	154	189	140	196
S5	127	187	162	195
Mean and SD	139 ± 13	185 ± 11	143 ± 16	185 ± 14

(HR_{TSmed}) mean heart rate during the training session; (HRTSmax) mximum heart rate during the training session.

The mean total time of the training session was 91.3 (11.9) minutes (CI95% = 82.0-100.5). From the analysis of the intensity distribution (figure 1) it was possible to confirm that the remaining time in zone 5 (90% to 100%), as well as at intensity below 50% HR_{max}, was statistically lower compared to the other zones. Most part of the training was performed within the range 60% to 89% of HR_{max}, which corresponds to zones 2, 3 and 4 of the used method[8] (figure 1).

Figure 2 presents that out of the 91.3 minutes (total time of TS duration), the karate fighters spent 72.5 minutes at intensity ≥ 60% of HR_{max}, according to the guidelines by the ACSM[11]so that satisfactory adaptations occur in the cardiorespiratory fitness. This time is equivalent to 79.9% (CI95% = 65.7-94.1%) of total time of TS.

The time spent at intensity below 50% of HR_{max} was minimum. From the individuals responses of HR of two volunteers (figure 3), it is evident the intermittent characteristic from moderate to high intensity during the training session.

The HR_{VT} and HR_{RCP} means of the group (n = 8) were equivalent, respectively, to 83% (CI95% = 80-85%) and 90% (CI95% = 87-92%) of HR_{TImax}. Although most of the training occurs between the 60% to 90% of HR_{TImax} intensity, during the TS the karate fighters remained predominately at intensity below the HR_{VT} (M = 80.4%; CI95% = 65.5-95.3%) and between HR_{VT} and HR_{RCP} (M = 15.4 %; CI95% = 4.7-26.2%). The VT and RCP data of one of the volunteers were lost due to technical problems in the O_2acquisition during the T_I.

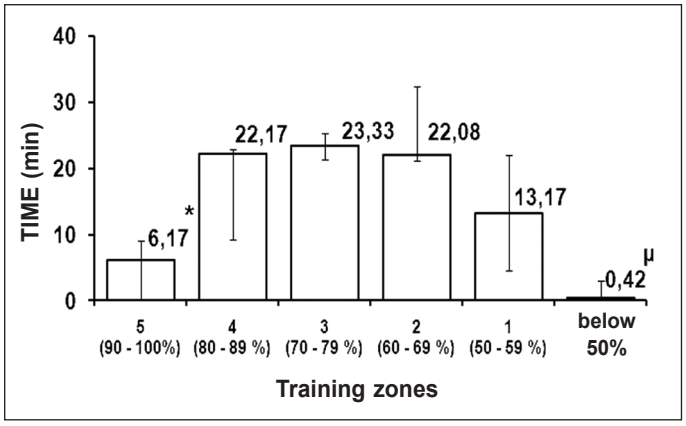

Figure 1. Distribution of the training intensities according to the method proposed by Edwards (1993) expressed in median (column, first quartile (upper error bar) and third quartile (lower error bar).
* Significant difference in relation to zones 4, 3 and 2 (P < 0.05);
μ Significant difference in relation to zones 4, 3, 2 and 1 (P < 0.05).

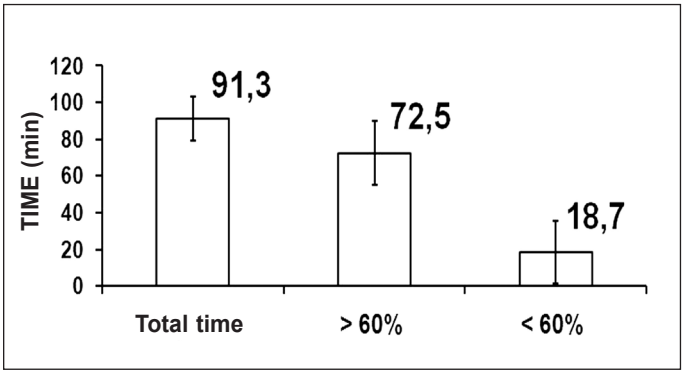

Figure 2. Total time of the TS and remaining time above (> 60%) and below (< 60%) 60% of HR_{TImax}.

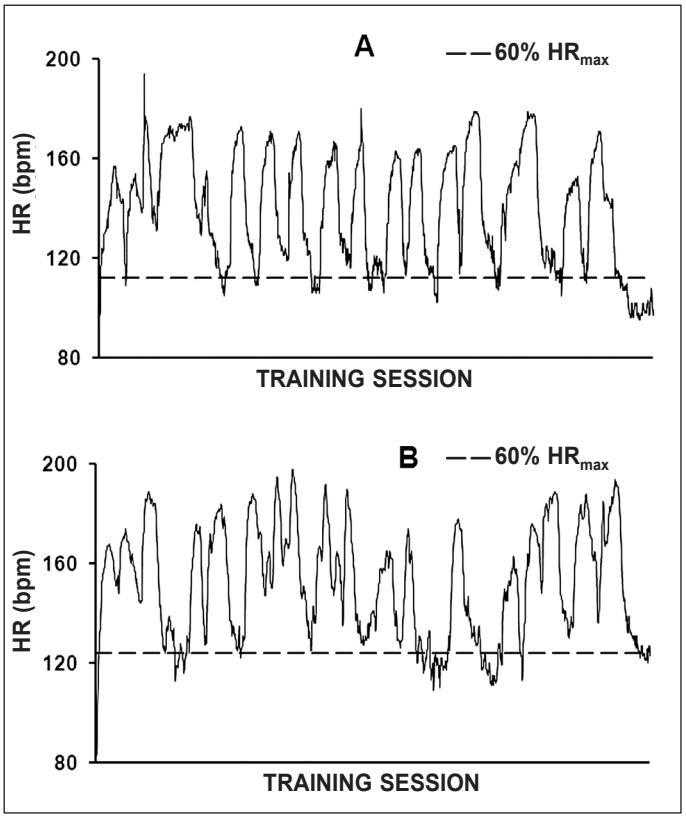

Figure 3. Individual data of HR during one karate session: A) male volunteer; B) female volunteer.

DISCUSSION

The main goal of the present study was to, through the HR monitoring; investigate the intensity distribution during one karate training session with preserved ecological validity in a trial to characterize the modality as an alternative activity for promotion of cardiorespiratory fitness. In Brazil,a review of the main national journals[19] checked that between 1998 and 2008 only six studies related to the karate modality were published. In the international literature until the present moment, great part of the studies which evaluated the HR response related to the karate modality focused their research on 'katas'[2], protocols pre-set by the researchers which simulated training[1,13,15] and presented HR_{Tmed} and HR_{TSmax} values lower than in our study. The protocols used in those studies compromise the ecological validity, since the duration time, actions and muscular groups involved present limitations facing what occurs in a conventional session. Moreover, the HR_{tsmean} response is considered a limited method for assessment of high intensity exercises with stochastic characteristics[20-22]. Therefore, in the present study, differently from the previous ones, we also analyzed the distribution of the exertion intensity performed by karate fighters duringa TS, without intervention from the researchers in the training time table adopted by the technical staff, keeping the ecological validity intact.

The results obtained during the TS indicate that the modality contemplates the duration and intensity requisites of the ACSM[11] for promotion of cardiorespiratory fitness. Out of the 91.3 minutes (total duration of the TS), 72.5 minutes the athletes remained at intensity ≥ 60% of HR_{max}, according to what was demonstrated in figure 2, equivalent to 79.9% of the total time of the TS. Therefore, most part

of the training was performed within the 60% to 90% of HR_{max}range, which corresponds to zones 2, 3 and 4 of the used method[18], while at the intensity below 60% of HR_{max}, the remaining was too short and below 50%; $HR_{max}$was minimum (42 sec) (figures 1 and 2).

In addition to that, it is possible to affirm that karate is characterized as an intermittent modality of moderate to high intensity, according to the illustration in figure 3 (A and B), corroborating previous studies[3,4] and other modalities of martial arts[23-25]. Training stimuli from modalities with intermittent characteristics are efficient in promoting the significant increase in $\dot{V}O_{2max}$o pre-puberty children[26], young adults, middle-aged[27]and elderly subjects[28], of both sexes[27], regardless of the training level, since the responses in the cardiorespiratory indices include from sedentary subjects to athletes[27,29].

The group analyzed in this study presented $\dot{V}O_{2max}$ values higher than the normative values[5,7,24] and similar to previous karate and other similar combat modalities studies. These results, joined with the results of previous studies of martial arts[5,23,24], let us infer that the volunteers who have cardiorespiratory fitness indices above the accepted level for promoting health and reducing risk of death. Additionally, according to the confidence intervals found for the aerobic fitness markers ($\dot{V}O_{2max}$, VT and RCP), it is possible to confirm that the group has homogeneous aerobic capacity above the population mean[7] and within the parameters recommended by the literature for reduction of risk to health[5,7,24]. High aerobic capacity contributes both to the supply and resynthesis of high energy phosphates during the activities and recovery, respectively[30], an important adaptation to the modality[3].

It is worth mentioning that this study presents some important limitations, such as lack of longitudinal follow-up of the sessions and the reduced number of analyzed subjects. However, nine athletes in nine different training sessions who presented values of mean HR of 72% of HR_{max} (CI95% = 66-78%) were monitored, demonstrating hence, similarity of the HR responses between sessions. Concerning the relatively low number of subjects who composed the sample, this is because of the way the athletes are categorized according with age and body mass, which causes the teams to normally have one athlete per category, a fact which has been frequently verified in the studies conducted with karate fighters ($n \leq 10$)[2,3,13,15]. Considering the limitations of the present study, it is possible to state that karate is an interesting alternative of physical exercises for promotion of cardiorespiratory fitness.

CONCLUSION

Based on the results observed in the present study, it is possible to state that the intensity of one karate TS with preserved ecological validity meets the recommendations of the ACSM concerning intensity, duration and weekly frequency, being an interesting alternative of physical exercise for promotion of cardiorespiratory fitness.

All authors have declared there is not any potential conflict of interests concerning this article.

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