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Physiological and perceived exertion responses during specific training of *Goju-Ryu Karate Kata*

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Summary

Introduction. This study aims (1) to determine the effects of *Kata Karate Goju-Ryu* training on heart rate (HR), blood lactate ([Lac]) and rating of perceived exertion (RPE), and (2) to clarify the association between RPE, HR and [Lac] on response to *Kata* training.

Material and methods. The sample was composed by 36 *Kata* performances, which were done by six male athletes. The assessments included anthropometric measures (age, 37±13 yrs.; stature, 1.81±0.07 m; body mass, 77.20±7.64 kg; fat mass, 24.72±6.79%) and the following physiological indicators: HR, intensity [($HR_{training}$ – HR_{basal}) / (HR_{max} – HR_{basal})], [Lac] and delta lactate (Δ[Lac]). The RPE was assessed after each *Kata* using the original version of Borg's 15-category scale (RPE_{6-20}) and after 30-minutes of the *Kata* training using the modified Borg's Category-Ratio (RPE_{CR-10}) scale.

Results. In spite of the results indicated a moderate metabolic rate of the *Kata* training (HR_{max}, 71.49%), with no significant differences between *Kata*. Mooreover, the both RPE Scale were not associated with effort intensity, [Lac] and Δ[Lac] (except for RPE_{CR-10} on the second and the fifth *Kata*).

Conclusions. The variability of the actions of the *Goju-Ryu Karate Kata* makes the aerobic metabolism the predominant source, what explain why the RPE_{6-20} was associated with effort intensity in trials, except on the second and the fifth *Kata*.

Introduction

Karate Kata are executed in pre-established sequences of defensive or/and offensive techniques and movements, generally with stepping and turning, while attempting to maintain perfect form [1,2]. Previous studies pointed that *Kata* have been claimed to contribute to increasing general physical fitness and cardiovascular fitness in practitioners [3,4]. Francescato, Talon and Di Prampero [5] studied energy sources in six *Kata* types with an increasing duration (from 10- to 80-seconds) performed per eight male practitioners. Results showed that, in 10-seconds of *Kata*, 90% of the energy derived from anaerobic alactic sources, in 80-seconds of *Kata*, only 46% corresponding to the same energetic system. Although, *Kata* training is often practiced per people who aiming to improve cardiovascular condition, none of previous studies reported above the rating of perceived exertion (RPE) during specific *Kata* training. It can be reasonably speculated that the perceived exertion response during fatiguing exercise will saturate an applied scale, such as the Borg category-ratio (RPE_{CR-10}) or 15-category scales.

The RPE evaluation implicates the combination of afferent feedback from cardiorespiratory, metabolic, and thermal stimuli and feed-forward mechanisms to enable an individual to evaluate how hard or easy an exercise task feels at any point in time [6]. Kazuhide et al. [7], aimed to investigate the duration of sequences of offensive and defensive techniques to the cardiovascular, metabolic, and perceptual responses during 2- and 3-minutes bouts of simulated *Karate* sparring. Effects showed significant difference between 2- and 3-minutes of *Kumite*. The heart rate (HR), RPE and energy expenditure were higher for 3-minute of combat simulation when compared with 2-minutes. Recently Milanez et al. [8], observed significant relationships between RPE-S and mean values of $\%HR_{max}$ (r = 0.91), $\%HR_{reserve}$ (r = 0.87), blood lactate ([Lac], r = 0.96), and RPE (r = 0.78) during the *Karate* training session, but not between RPE-S and the duration of exercise bout (r = −0.28, P > 0.05).

In general, *Karate* research based on associations between RPE, specific tasks or combat simulations (*Kumite*), blood lactate concentration ([Lac]) and/or HR, demonstrated nonconsensual results [9-11;14]. Imamura et al. [15] observed changes in HR and RPE of 20 consecutive *Karate* sparring matches, each of 2-minutes duration. The mean HR was 191.8± 9.4 $beats.min^{-1}$ and the RPE obtained was 19±2 score. In

other study [11], the authors observed physiological responses of male collegiate *Karate* practitioners in two different groups (high skilled and novices) after performing 1.000 punches and 1.000 kicks. The results of high skilled and novices of the mean values HR, [Lac] and RPE in 1.000 punches were 102.5±14.8 and 116.1±17.9 beats·min^{-1}, 0.8±0.2 and 1.2±0.6 mmol·l^{-1}, and 12.2±1.2 and 12.8±1.2, respectively. Regarding 1.000 kicks 127.4±12.4 and 137.0±14.4 beats·min^{-1}, 1.3±0.4 and 2.4±0.8 mmol·l^{-1} and 14.2±1.2 and 16.3±1.5, respectively. These responses were significantly lower than the RPE expected by the coaches [11]. Recently, the Foster's RPE-based approach was applied to quantify internal training load (TL) during *Karate* training sessions with young *Karate* practitioners and the findings demonstrated significant correlations between this method and other published methods based on the HR response to exercise. Specifically, the authors determined the correlations (r = 0.63) between session-RPE and two HR-based methods widely considered to be valid indicators of internal TL during modes of training sessions. Moreover, the previous studies are not consensual [12]. Thus, since greater understanding of *Kata* and physiological parameters will assist coaches, scientific experts, and even athletes in the best way to optimize sport specific training programs and consequently enhance *Karate*'s high-level performance [13], a study conducted with *Kata* environment seems to be needed.

Assuming that the *Kata* training situation is distinct and different from sparring situations or other specific exercises, the current study hypothesized the existence of a relation between RPE and the effort intensity in *Kata* training session. Therefore, the purpose of this study (1) to determine the effects of *Kata Karate Goju-Ryu* training on HR, [Lac] and RPE, and (2) to clarify the association between RPE, HR and [Lac] on response to *Kata* training.

Material and methods

Experimental Approach to the Problem

This was a randomized study where subjects participated in one experimental session. The session was set up to determinate the heart rate (HR), blood lactate ([Lac]) and rating of perceived exertion (RPE) responses during the training of *Goju-Ryu Karate Kata*. The session was conducted between 19 p.m. and 21 p.m. at an average room temperature of 22ºC, with similar conditions to all *Kata* trials.

Participants

The sample was composed by 36 *Kata* performances, which were done by six male athletes (age, 37±13 yrs.; stature, 1.81±0.07 m; body mass, 77.20±7.64 kg; fat mass, 24.72± 6.79%). The subjects were volunteers from the Local *Karate Goju-Ryu* Federation. The criteria for inclusion was to be a black belt and to practicing *Karate Goju-Ryu* for at least ten years and to training *Kata* at a minimum of three per week, with a minimum of 90 min per day. This study was submitted to and approved by the Local Committee of Ethics in Research. All study participants took part voluntarily after being informed about the risks and benefits of the procedures involved and signed an informed consent form that was previously approved by the Ethics Committee.

Experimental protocol

Before the experimental protocol all participants realized an anthropometric valuation. After familiarization with the procedures and a free warm-up, each athlete underwent a total of six trials in one session with a recovery of two minutes between trials, protocol adapted of Invernizzi, Longo and Scurati [2]. The *Kata* trials with their minimal and maximal work time were: (i) *Gekisai Dai Ichi* (T1), 31- to 33-seconds; (ii) *Gekisai Dai Ni* (T2), 35- to 38-seconds; (iii) *Saifa* (T3), 39- to 40-seconds; (iv) *Seyunchi* (T4), 81-seconds; (v) *Shisochin* (T5), 59- to 57-seconds; and (vi) *Sanseru* (T6), 54- to 55-seconds.

Before the *Kata* training session, the anthropometrical measures were done, following Marfell-Jones et al. [16]: body mass and fat percentage by bioimpedance (both of weighing-machine Beurer BG 42, Ulm, Germany) and stature (GPM, Siber-Hegner, Switzerland, 2008).

Physiological and RPE assessments were carried out during the six different trials of *Goju-Ryu Kata*. The present study registered two physiological measures (HR; [Lac]) and two RPE evaluations (RPE_{6-20}; RPE_{CR-10}). In addition, it was calculated the variation of [Lac] (Δ[Lac]) with the registered values, as with the referential T0 moment, and the values registered after each *Kata* trial (T1, T2, T3, T4, T5 e T6). Moreover, the intensity of the effort in each *Kata* trial was calculated with the equation: Intensity = $(HR_{training} - HR_{basal}) / (HR_{max} - HR_{basal})$.

The [Lac] of finger capillary blood was determined with blood samples of 25 µl expressed by mmol/L, which were measured before the first *Kata* and after each trial (Lactate Pro LT – 1710™, Arkray, Inc., Düsseldorf, Germany). At the same time, the HR were measured by beats per minute (beats·min^{-1}) using Polar® Model RS400 (Kempele, Finland).

A rating of perceived exertion with the scale of 6-20 (RPE_{6-20}) [17] were used to determine the subjects' perception of effort at the completion of each *Kata* trial. After 30-minutes of *Kata* training, the rating of perception of effort modified with the scale of 0-10 (RPE_{CR-10}) was used to determine the sample 'perception of effort' [17]. The study design is presented graphically in Figure 1.

Statistical Analysis

The present research used the PASW Statistics software (v.20, SPSS Inc, Chicago, IL) to do measures of centrality and dispersion, which are shown as mean ± SD. ANOVA with repeated measures was conducted to compare measured variables. A Mauchly's test of sphericity was used to check the repeated measures analysis of variance. If differences were detected, the Bonferroni test would be used as a *post hoc* test to identify specific differences among *Kata* trials. Pearson coefficient was used to measure the correlation between the variables [Lac], Δ[Lac], RPE_{6-20} and RPE_{CR-10}. For all analysis, a significant level of $P \leq 0.05$ was established.

Results

Statistical analysis did not detect effects between the *Kata* trials intensity exercise, with an index of 71.49%. The effort intensity of the *Kata* trials is shown in the Figure 2.

No difference was perceived when compared the RPE_{CR-10} related with the [Lac], and when associated the RPE_{CR-10} with the Δ[Lac], except for the 5th moment (i.e., T5). Moreover, the association between the effort intensity and the both scales of RPE was statistically correlated with the 2nd moment (i.e. T2:

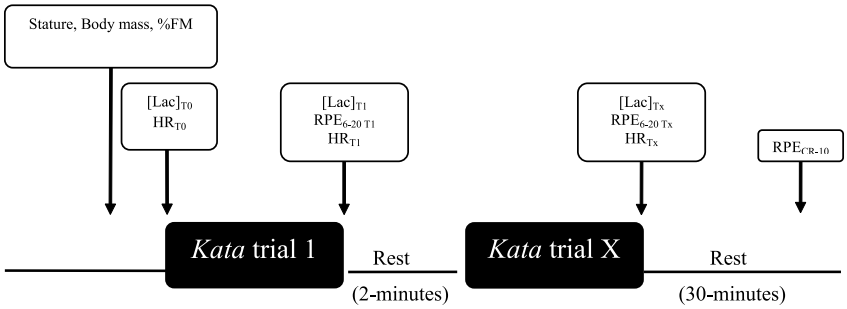

Figure 1. Study design

Table 1. Descriptive results of physiological measurements and RPE

Time (*Kata*)	HR (beats/min)	[Lac] (mmol/l)	RPE_{6-20} (score)
T0	68±09	1.7±0.6	6.0±0.0
T1 (*Gekisai Dai Ichi*)	137±14	3.9±2.5	10.3±1.0
T2 (*Gekisai Dai Ni*)	145±08	5.7±3.6	10.2±1.6
T3 (*Saifa*)	139±35	5.1±4.2	10.5±1.2
T4 (*Seyunchin*)	155±14	7.0±4.0	12.0±1.0
T5 (*Shisochin*)	160±06	3.9±1.7	11.5±0.5
T6 (*Sanseru*)	156±10	5.4±1.5	11.5±0.8
Mean of training session	149±12	5.2±3.0	11.0±1.0

Table 2. Correlation (r) between physiological measurements, the effort intensity and the RPE (Borg 6-20 and CR-10)

Kata trials	RPE_{6-20}			RPE_{CR-10}			
	Effort Intensity	[Lac]	Δ[Lac]	Effort Intensity	[Lac]	Δ[Lac]	RPE_{6-20}
T1 (*Gekisai Dai Ichi*)	0.591	0.316	0.257	0.749	0.200	0.075	0.632
T2 (*Gekisai Dai Ni*)	0.114	-0.535	-0.551	0.855*	0.338	0.326	0.051
T3 (*Saifa*)	0.560	0.410	0.340	-0.104	0.335	0.297	-0.200
T4 (*Seyunchin*)	0.422	-0.382	-0.360	-0.010	0.063	0.008	-0.270
T5 (*Shisochin*)	0.230	0.433	0.598	0.279	-0.822*	-0.834*	-0.632
T6 (*Sanseru*)	0.770	0.525	0.444	0.412	-0.239	-0.346	0.293

Legend: *, strong correlation with $P < 0.05$.

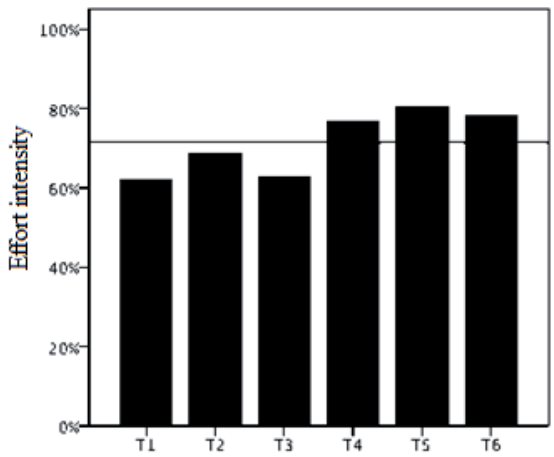

Figure 2. Graph of the intensity of the Kata trials

Gekisai Dai Ni) and with the results of the Borg scale application (i.e.,10). The following Table-1 presents the mean±SD of HR, [Lac] and RPE_{6-20} per sequential trial analyzed during the *Goju-Ryu Karate Kata* training.

The Pearson Coefficient Correlation Analysis demonstrated: (1) strong and moderate association between RPE_{6-20} and effort intensity, except in 2nd and 5th moments; and (2) significant association between the RPE_{CR-10} scale with effort intensity (T2), [Lac] and Δ[Lac] (on the fifth *Kata*). The results are shown in Table-2.

Discussion

Results showed no differences, between the trials of *Kata Karate Goju-Ryu* training, on HR, [La] and RPE. In addition, the Pearson coefficient correlation analysis demonstrated strong or moderate association between RPE_{6-20}, and the effort intensity, except in the 2nd and 5th moment. Considerations of type I and type II error need to be assumed according the limitation of the present research which was the small sample. This aspect could influence the association between RPE_{6-20} and effort intensity, as the link between RPE_{6-20} and [Lac]. Invernizzi and collegues [2], who made a pilot study in three *Karate Kata* world champions, verified a significant difference between the first and the last trial. Different from the present study, they indicated a decreasing trend in both HR and [Lac] across the four trials (HR: -2%, -4.2%, -2.9% and -3.2%; [Lac]: -23.6%, -32.6%, -18% and -15.9%).

In our research, the mean values of HR, [Lac], RPE_{6-20}, RPE_{CR-10} and intensity index calculated in *Kata* trials training were 149±12 beats·min^{-1}, 5.2±3.0 mmol·l^{-1}, 11.0±1.0 score score, 1.8±0.6 score and 71.49%, respectively. These data are in arrangement with Beneke et al. [18], who suggested that the non-pattern profile which includes more or less frequent forward, backward and sidesteps, hopping activities, combined with short bouts of extreme techniques that have high-energy requirements and subsequent short breaks, cause a metabolic profile in which aerobic metabolism is the predominant source.

Doria et al. [19], compared *Kumite* and *Kata* energy contribution during a simulated competition. They revealed that aerobic energy source is the predominant source (50-74% of the total) in both activities without differences between them. The lactic source represents the lowest percentage (12-22%) of energy used, and the alactic intermediate (14-28%). However, *Kata* used twice as much alactic source than *Kumite* athletes. This aspect could explain why our physiological results were higher than presented per Imamura et al. [11], which observed in beginners and experts the following values 102.5±14.8 and 116.1±17.9 beats·min^{-1} (HR), 0.8±0.2 and 1.2±0.6 mmol·l^{-1} ([Lac]), and 12.2±1.2 and 12.8±1.2 score (RPE), respectively. Regarding 1.000 kicks 127.4±12.4 and 137.0±14.4 beats·min^{-1} (HR), 1.3±0.4 and 2.4±0.8 mmol·l^{-1} ([Lac]), and 14.2±1.2 and 16.3±1.5 score (RPE), respectively.

Concluding, preceding reports in general showed that RPE has been associated with Kumite [3] and training sessions [12] of *Karate* with physiological measures, for instance, oxygen consumption (V-dot-O_2), ventilation, respiratory rate, [Lac] and HR [3,11]. In the present research, were observed the effects of *Kata Karate Goju-Ryu* training on HR, [Lac] and RPE, after, to observe the association among these variables. In fact, the result supports preceding authors, who also showed that session-RPE method make available a practical, low-cost, and non invasive tool of quantifying *Karate Kata* training loads, making it an appreciated tool for practitioners and coaches [12].

Conclusions

The present study is the first successful approach to analyze the effort profile of *Karate Kata Goju-Ryu* based on the measurement of the results, which indicated a moderate metabolic rate (HR_{max}, 71.49%) to the Kata training session with no significant differences between *Kata*. The variability of the actions of the *Goju-Ryu Karate Kata* cause a metabolic profile in which the aerobic metabolism is the predominant source, what explain why the RPE_{6-20} was associated with effort intensity in Kata trials (except in 2nd and 5th trials). Nevertheless, some considerations of type I and type II error needs to be assumed, before the use of the RPE_{6-20} in training *Kata* sessions.

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