APPLICATION OF DIFFERENT LOAD QUANTIFICATION METHODS DURING A KARATE TRAINING SESSION

Review Article

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ABSTRACT

The ratings of perceived exertion (RPE) of the session have stood out among the methods of load training quantification (LTQ) in some modalities, mainly due to their low cost and easy applicability. However, there are no reports in the literature on their application in the karate modality. The aim of this study was to analyze the relationship between session-RPE with $Banister_{TRIMP}$, $Edwards_{TL}$, $Lucia_{TRIMP}$, $Stagno_{TRIMP}$ and Lac_{TRIMP}. Eight well-trained athletes of both sexes (21.6 ± 5.5 years; 58.8 ± 13.8 weight; 170.0 ± 0.11 height) performed a single training session with continuous heart rate monitoring, blood lactate collections every 10 min and RPE quantification through the CR-10 scale, 30 min after the end of the training, for subsequent calculation of training impulse. Significant correlations ($P<0.05$) were found between session-RPE and $Banister_{TRIMP}$ ($r = 0.79$), $Edward_{TL}$ ($r = 0.81$), $Lucia_{TRIMP}$ ($r = 0.71$), $Stagno_{TRIMP}$ ($r = 0.71$) and Lac_{TRIMP} ($r = 0.91$). Thus, the results of this study suggest the session-RPE as an efficient method from the LTQ in shotokan karate athletes.

Keywords: heart rate, martial arts, rating of perceived exertion

INTRODUCTION

Karate is one of the most practiced martial arts in the world[1], and the athletes who aim competition are submitted to extenuating training sessions for their technical and physical improvement. The training process designed by the coaches has the aim to maximize sports performance[2], and the athletes success depends on the accurate monitoring of the internal training load (TL)[3]. Thus, the (TL) monitoring, besides being an important component to lead the athlete to the peak of the planned performance[4] is an efficient instrument for overtraining prevention[5,6].

In order to quantify the TL, there are many methods which are based on training impulse (TRIMP), measures which integrate exercise volume and intensity and which can be obtained from the heart rate responses (HR)[7-10], of the lactate blood concentration (Lac_{TRIMP})[11] and rating of perceived exertion (session-RPE)[12].

The methods based on the HR response are widely used in endurance modalities[9,13,14]; however, they are considered inefficient to quantify the TL in some exercises, such as resistance training (RT), interval training or plyometric exercises[15-17]. In addition to that, the method requires the presence of experienced evaluators, besides demanding high cost for acquisition and maintenance of many cardiofrequencimeter[16].

Although it checks the objective measures in a similar way to the methods based on the HR response, the method based on the blood lactate concentration [La] also presents some limitations, since the procedure used for the blood collections is invasive and unpleasant for most of the athletes[18], added to the high cost of the analyses and constant interruption of the training for the blood collections, which makes it difficult to use the Lac_{TRIMP} method proposed by Seiler and Kjerland[11].

Alternatively, the session-RPE method has been considered one of the main techniques for the TL quantification described in the scientific literature, with special attention due to its low financial cost and practicality. Good correlations between session-RPE and the methods based on HR and [La] were found in continuous exercises[,11,12,15]. In swimming, Wallace et al.[19] found significant correlations ($r = 0.55 – 0.94$; $P < 0.05$) between session-RPE and the methods based on the HR. However, there is limited information about the correlation between session-RPE and the TRIMPs methods based on physiological parameters in modalities with intermittent characteristics, especially in karate.

Thus, the aim of this study was to assess the relationship of the session-RPE method and $Banister_{TRIMP}$, $Edwards_{TL}$, $Lucia_{TRIMP}$, $Stagno_{TRIMP}$ and Lac_{TRIMP} during a karate training session.

METHODS

Subjects

The sample was composed of eight karate fighters of both sexes, practitioners of the shotokan style, which is guided by the World Karate Federation, with five brown and three black belts, affiliated with the Brazilian Confederation of Karate with experience in national and international competitions. The athletes regularly trained for a minimum period of five times a week, for at least five years. The experimental protocol was approved by the Local Ethics in Research Committee, according to the Resolution 196/96 of the National Health Board (law 192/07). All subjects were informed about the procedures to be performed, the risks and benefits associated with the participation in the study and signed a Free and Clarified Consent Form.

Experimental outlining

Initially, the athletes performed a protocol composed of anthropometric evaluation, rest heart rate evaluation (HRres) and a maximal incremental test on treadmill (Super ATL, Inbrasport, Brazil). Subsequently, they performed one training session with HR monitoring, blood samples collection and RPE measurement through the CR-10 RPE scale. The subjects were familiarized with the procedures, equipment, RPE scale and told not to perform intense exertion or ingest alcoholic drinks in the 24 prior the tests, or ingest caffeinated food and drinks in the three hours before the tests. All stages were separated by a minimal interval of 48 hours.

Incremental test

Initial velocities were individually calculated from the maximal velocity test and ranged between 6 and 8km.h^{-1}. Inclination was kept at 1% and the 1km.h^{-1} increment was performed at every three minutes until voluntary exhaustion. During the entire progressive test, the HR was recorded using monitor Polar(S810i, Polar Electo Oy, Kempele, Finland), and the pulmonary gas exchanges were recorded at every 20 seconds through a gas analyzer VO2000 (MedGraphics, USA). The gas analyzer calibration was performed before each test from a room gas sample and known O_2 (16%) and CO_2 (5%) gas concentrations. The gas flow to the instrument was also calibrated through a syringe with three liters of volume. The maximal heart rate (HR_{max}) was considered as the mean of the HR record of the last 30 seconds of the progressive test. In order to have the maximal oxygen consumption value (VO_2max) accepted, the criteria suggested by Billat et al.[20] were adopted. The ventilatory threshold (VT) and the respiratory compensation point (RCP) were determined according to the procedure suggested by Lucia et al.[9].

Training session (TS)

During the TS, the temperature was kept between 23 and 26 degrees, and in the beginning, the athletes performed a short warm-up and stretching, both non-standardized and with approximate duration of 20 minutes. Each training session had mean duration of 91.9 minutes, separated in small effort bouts with two-minute duration in which attack techniques with punches and kicks, defense techniques, counter-attack with punches and kicks with no opponent were performed. The movements were repeated in the presence of opponents and with addition of fall techniques. Small intervals were given between shifts with duration between 30 and 60 seconds for technique alterations, of the opponent or for rest, according to the daily training routine of the athletes.

The HR monitor was strategically positioned on the athlete's back, attached near the transmission tape inside the kimono to protect the instrument and preserve the physical integrity of the athletes. The karate training session occurred with constant monitoring of HR, blood samples collection at every 10 minutes and RPE measurement through the Borg CR-10 scale, modified by Foster et al.[12], 30 minutes after the end of the training session, for subsequent calculation of the training impulses.

Quantification by the $Banister_{TRIMP}$ method

The calculation of the training load proposed by Banister[7] was performed through the following formula:

$TRIMP = TD * HR_R * 0.64 * e^{1.92*HR_R}$ (men)

$TRIMP = TD * HR_R * 0.86 * e^{1.672*HR_R}$ (women)

Where TD is the training session duration expressed in minutes and the reserve HR (HR_R) was determined by the following equation:

$HR_R = (HR_{ST} - HR_B) / (HR_{max} - HR_B)$

Where HR_{ST} was the mean HR of the session, HR_B was the rest HR.

Quantification by the $Edwards_{TL}$ method

The quantification of the training load by the Edwards[8] method was performed from the division of intensity zones related to HR_{max} (zone 1: 50 at 60% of HR_{max}; zone 2: 60 at 70% of HR_{max}; zone 3: 70 at 80% of HR_{max}; zone 4: 80 at 90% of HR_{max}; zone 5: 90 at 100% of HR_{max}). The records below 50% of HR_{max} were discarded. For estimation of the $Edwards_{TL}$, the time accumulated in each zone was multiplied by its value and the results obtained were summed.

Quantification by the $Lucia_{TRIMP}$ method

During the VO_2max incremental test in laboratory, the times concerning the VT and RCP were determined. The HR concerning the VT and RCP were found through the HR/time ratio. Based on these HR values, three intensity zones were determined: zone 1, below the VT; zone 2, between the VT and the RCP; and zone 3, above the RCP. For calculation of the $Lucia_{TRIMP}$ the time accumulated in each of the three zones was multiplied by the value respective to it, and the results obtained in the multiplications were then added.

Quantification by the $Stagno_{TRIMP}$ method

The calculation fo the training load proposed by Stagno[10] was performed through the following formula:

$TRIMP = duration* HR_R * 0.1225 * e^{3.9434*HR_R}$

Where, HR_R was the reserve heart rate determined by the equation:

$HR_R = (HR_{ST} - HR_B) / (HR_{max} - HR_B)$

Quantification by the Lac_{TRIMP} method

In order to calculate the training load through [La] three intensity zones were adopted (zone 1: [La] ≤ 2, zone 2: 2 > [La] < 4, zone 3: [La] ≥ 4) according to the method used by Seiler and Kjerland[11]. A relative coefficient was attributed to each one of these zones (k = 1, for zone 1; k = 2, for zone 2; and k = 3, for zone 3). The Lac_{TRIMP} was calculated by the sum of the multiplications of the times spent in the different zones by the coefficient relative to each zone.

25µl of blood were collected with heparinized capillaries for analysis of the [La]. The blood was collected from the earlobes of the athletes at every 10 minutes of the training session. At the moment of the collections, 60 seconds of rest were performed. Immediately after the collections, the blood was stored in Eppendorf tubes with 50µl of sodium fluoride 1%. The blood lactate was analyzed in a lactimeter brand name YSL 1500 STAT SPORT (Yellow Spring Co, USA).

Quantification by the session-RPE method

In order to quantify the TL through the session-RPE, the product between accumulated training duration in minutes and the value pointes on the CR-10 RPE scale modified by Foster et al.[12] was calculated. The scale was presented to the athletes 30 minutes after the end of the TS, quantifying hence the exertion referring to the total of the session. All athletes were familiarized with the CR-10 RPE scale for at least two years.

Statistical analysis

The results are expressed in mean and standard deviation (±). The data distribution within the normality curve was verified by the Shapiro Wilk test. The Spearman correlation analysis was used to verify the possible associations between methods. The significance level was set at 5%. The data were treated using the SPSS program for Windows, version 13.0.

RESULTS

The anthropometric and physiological characteristics of the karate fighters are presented in mean and standard deviation in table 1. The mean duration of the training sessions was of 91.9 ± 12 minutes.

In table 2 the correlations between ($Edwards_{TL}$ versus $Banister_{TRIMP}$; $Edwards_{TL}$ versus $Lucia_{TRIMP}$; $Edwards_{TL}$ versus $Stagno_{TRIMP}$; $Edwards_{TL}$ versus Lac_{TRIMP}; $Lucia_{TRIMP}$ versus Lac_{TRIMP}; $Banister_{TRIMP}$ versus $Stagno_{TRIMP}$) are presented.

There was strong relationship between the session-RPE and $Edwards_{TL}$, $Lucia_{TRIMP}$, Lac_{TRIMP}, $Banister_{TRIMP}$ and $Stagno_{TRIMP}$ as presented in figure 1. The correlation analysis demonstrated shared variations of 66%, 51%, 82%, 62% and 51% between session-RPE and the $Edwards_{TL}$, $Lucia_{TRIMP}$, Lac_{TRIMP}, $Banister_{TRIMP}$, $Stagno_{TRIMP}$ methods, respectively.

Table1. Anthropometric and physiological characteristics of the subjects presented in mean and standard deviation values (±).

	Men (n = 4)	Women (n = 4)
Age (years)	23.8 ± 7.3	19.5 ± 2.1
Height (cm)	170 ± 10.7	162.5 ± 3.5
Body weight (kg)	64.5 ± 18	55.1 ± 7.7
Body fat (%)	7.4 ± 5.6	15.2 ± 3.6
VO_{2max} ($mL.kg^{-1}.min^{-1}$)	51.8 ± 6.9	41.9 ± 5.5
HR_{max} (bpm)	202 ± 3.4	192.5 ± 3.8

Table 2. Relationship of the TL estimations among the $Banister_{TRIMP}$, $Edwards_{TL}$, $Lucia_{TRIMP}$, $Stagno_{TRIMP}$ and Lac_{TRIMP} methods.

	$Banister_{TRIMP}$	$Edwards_{TL}$	$Lucia_{TRIMP}$	$Stagno_{TRIMP}$
$Banister_{TRIMP}$	-----	-----	-----	-----
$Edwards_{TL}$	r = 0.88**	-----	-----	-----
$Lucia_{TRIMP}$	r = 0.61	r = 0.76*	-----	-----
$Stagno_{TRIMP}$	r = 0.98**	r = 0.86**	r = 0.64	-----
Lac_{TRIMP}	r = 0.69	r = 0.86**	r = 0.91**	r = 0.67

* $P < 0,05$; ** $P < 0,01$.

DISCUSSION

The aim of this study was to correlate different methods of TL quantification based on the HR responses[7-10], in the lactate blood concentration [La][11] and RPE[12]. There were from moderate to strong relationship (r = 0.61 to 0.98) between the TRIMPs methods based on the HR response and [La] (table 2). However, the main results of the present study are illustrated in figure 1, where the strong correlations found between methods based on the HR and [La] responses with the session-RPE method are demonstrated.

The correlation found between session-RPE and $Banister_{TRIMP}$ (r = 0.79) in the present study was similar to the results found in different sports modalities, especially with intermittent character, such as rugby (r = 0.46 – 0.94)[21], men's soccer (r = 0.50 – 0.77)[16] and women's soccer (r = 0.84)[22]. However, the $Banister_{TRIMP}$ method is limited to evaluation of high intensity exercises, such as WT, high intensity interval training and plyometric training[15-17]. The $Banister_{TRIMP}$ technique uses the mean HR_R of the session in its equation for quantification of training load, and its estimation is limited to high intensity intermittent exercises, since the HR_R mean for these exercise models does not represent the real intensity performed[17].

The session-RPE also presented strong correlation with the $Edwards_{TL}$ method (r = 0.81), corroborating the findings by Impellizzeri et al.[16] in men's soccer (r = 0.54 – 0.78), and by Alexiou and Coutts[22] in women's soccer (r = 0.85). According to Borresen and Lambert[17], like the $Banister_{TRIMP}$ method, the intensity estimation through this method is overestimated when compared to the session-RPE, since there is wide amplitude of the HR values within each exercise intensity zone, but it receives the same relative coefficient for the TL multiplication. Moreover, the variation of only one beat can alter the multiplication relative coefficient, being able to disproportionally increase or decrease the TL quantification.

The correlation between session-RPE and the $Lucia_{TRIMP}$ method (r = 0.71) is similar to the correlation found by Impellizzeri et al.[16] in men's soccer (r = 0.61 – 0.85). Originally developed to quantify TL or the load relative to competitions in endurance modalities, $Lucia_{TRIMP}$ considers the relation between HR and time to find HR values relative to VT and RCP and is more commonly applied in modalities such as cycling[9,13,14]. Foster[5] found Strong correlation between session-RPE and the $Lucia_{TRIMP}$ method (r = 0.75 – 0.90) for this kind of modality.

Strong correlation was found between session-RPE and $Stagno_{TRIMP}$ (r = 0.71). Specially developed to quantify TL in team sports, $Stagno_{TRIMP}$ has its equation based on the multiplication of a constant representative of the exponential increase of [La] in relation to the HR_R increase of hockey athletes; however, its formula does not include female athletes. Since it is a recent method, there are no data in the literature which correlates it to the session-RPE method, which made the comparison with our findings impossible.

The strongest correlation found in this study was between session-RPE versus Lac_{TRIMP} (r = 0.91), which demonstrated 82% of shared variation between methods. This correlation is higher

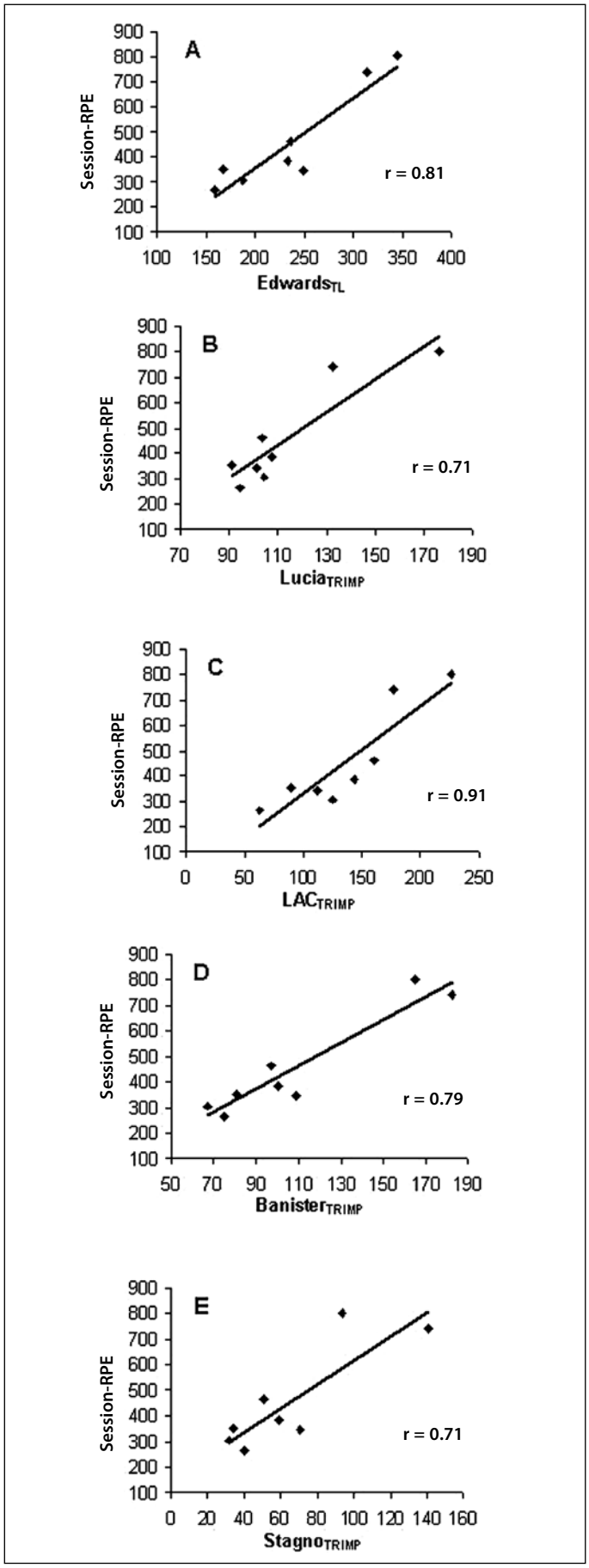

Figure 1. Relationship of the load quantification methods: (A) RPE of the session and Edwards$_{TL}$, (B) RPE of the session and Lucia$_{TRIMP}$, (C) RPE of the session and Lac$_{TRIMP}$, (D) RPE of the session and Banister$_{TRIMP}$, (E) RPE of the session and Stagno$_{TRIMP}$. All correlations were significant ($P < 0.05$).

than the one found by Alexiou and Coutts[22] (r = 0.85) and Wallace et al.[19] (r = 0.75) in women's soccer and swimming, respectively. However, the Lac$_{TRIMP}$ method requires relatively sophisticated equipment and expertise for the analyses. The fact it is an invasive procedure does not please the majority of the individuals[18], and the constant training interruption for the blood collection procedure makes the application of the method proposed by Seiler and Kjerland difficult[11]. A possible explanation for this strong correlation is the remarkable contribution of the anaerobic metabolism during high intensity intermittent exercises[16], which, on its turn, is the main way responsible for the lactate production and release to the blood. This physiological phenomenon has direct relation with the blood pH decrease, and with the consequent increase of PCO2 promoted by the respiratory buffering mechanism, which, besides forcing the respiratory centers in the bulb, also promotes sensation of intense exertion and fatigue, which directly influences the RPE.

The TL quantification methods based on the HR used in the present study have been frequently adopted as validation criteria for the session-RPE[16,17,19,22]. Nevertheless, it may not be suitable to quantify the training load from the cardiovascular responses in intermittent activities with high contribution of the anaerobic metabolism. In the study by Alexiou and Coutts[22], when the TL quantification analyses were separated by kind of training, the correlation between RPE and the methods based on the HR response for WT was of only (r = 0.25 – 0.52). On the other hand, Day et al.[23] reported strong correlation between session-RPE and different intensities (50, 70 and 90% of one repetition maximal), a gold-standard method for strength assessment, suggesting hence that the low correlation found in previous studies[22] may be attributed to the method based on the HR and not to the session-RPE method.

Exercises as karate, characterized by intense activities with short duration, including attack with punches and kicks, besides counter-attack, intercalated with small pauses for recovery, demand high participation both o the aerobic metabolism and the anaerobic one. Consequently, a method which does not consider these two systems, may not accurately represent the internal exertion load.

Coutts et al.[24] demonstrated through multiple regression analyses that [La] and HR values associated with an explanation coefficient for the increase of RPE of 57.8%, which was higher than the explanation coefficient values when the HR was independently analyzed (43.1%). These results suggest important participation of the anaerobic metabolism in the increase of RPE, which may be underestimated when only the HR is used as parameter, since the HR presents linear behavior with intensity, while the [La] presents exponential behavior.

Thus, the session-RPE seems to be a good parameter to quantify training loads, since it satisfactorily represents the participation of both systems, aerobic and anaerobic. Additionally, the session-RPE method does not require sophisticated equipment and hence can be easily applied by coaches and physical trainers to monitor the TL, besides being able to develop more efficient periodization strategies specific to athletes[3]. Although the present study had only evaluated one training session for each athlete, the results in the literature[16,21,22] associated with the

ones found in this study demonstrate that the session-RPE seems to be a good TL global indicator in intermittent sports modalities such as karate. However, further studies should be carried out so that a larger number of training sessions and subjects can be contemplated.

CONCLUSION

According to the results found in the present study, session-RPE seems to be a good method for helping the coaches and physical trainers in the quantification of the TL in Shotokan karate.

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