APPLICATION OF DIFFERENT LOAD QUANTIFICATION METHODS DURING A KARATE TRAINING SESSION

INTRODUCTION

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

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) of the lactate blood concentration (LacTRIMP) and rating of perceived exertion (session-RPE). The methods based on the HR response are widely used in endurance modalities; however, they are considered inefficient to quantify the TL in some exercises, such as resistance training (RT), interval training or plyometric exercises. In addition to that, the method requires the presence of experienced evaluators, besides demanding high cost for acquisition and maintenance of many cardiofrequencimenter.

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, 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 LacTRIMP method proposed by Seiler and Kjerland.

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. In swimming, Wallace et al. 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 BanisterTRIMP, EdwardsTL, LuciaTRIMP, StagnoTRIMP and LacTRIMP 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.

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 BanisterTRIMP, EdwardsTL, LuciaTRIMP, StagnoTRIMP and LacTRIMP. 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 BanisterTRIMP (r = 0.79), EdwardsTL (r = 0.81), LuciaTRIMP (r = 0.71), StagnoTRIMP (r = 0.71) and LacTRIMP (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.
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 8 km.h⁻¹. Inclination was kept at 1% and the 1 km.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 Electro 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 O₂(16%) and CO₂(5%) gas concentrations. The gas flow to the instrument was also calibrated through a syringe with three liters of volume. The maximal heart rate (HRmax) 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 (VO₂max) a mean of the HR record of the last 30 seconds of the progressive test. The records below 50% of HR max were discarded. For estimation of the Edwards-TRIMP, the time accumulated in each zone was multiplied by its value and the results obtained were summed.

Quantification by the Edwards-TRIMP method

The quantification of the training load by the Edwards⁹ method was performed from the division of intensity zones related to HRmax (zone 1: 50 at 60% of HRmax, zone 2: 60 at 70% of HRmax, zone 3: 70 at 80% of HRmax, zone 4: 80 at 90% of HRmax, zone 5: 90 at 100% of HRmax). The records below 50% of HRmax were discarded. For estimation of the Edwards-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 Lucia-TRIMP method

During the VO₂max 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 for the training load proposed by Stagno¹⁰ was performed through the following formula:

TRIMP = duration* HRb * 0.1225 * and 3.0417*HRr

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

HRb = (HRst – HRres) / (HRmax – HRres)

Quantification by the Lac-TRIMP method

In order to calculate the training load through [La] three intensity zones were adopted (zone 1: [La] ≤ 4, zone 2: 2 > [La] < 4, zone 3: [La] ≥ 4) according to the method used by Seiler and Kjerland¹¹. 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.

25 µl 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 50 µl 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 (EdwardsTL versus BanisterTRIMP; EdwardsTL versus LuciaTRIMP; EdwardsTL versus StagnoTRIMP; EdwardsTL versus LacTRIMP; LuciaTRIMP versus LacTRIMP; BanisterTRIMP versus StagnoTRIMP versus StagnoTRIMP) are presented.

There was strong relationship between the session-RPE and EdwardsTL, LuciaTRIMP, LacTRIMP, BanisterTRIMP and StagnoTRIMP as presented in figure 1. The correlation analysis demonstrated shared variations of 66%, 51%, 82%, 62% and 51% between session-RPE and the EdwardsTL, LuciaTRIMP, LacTRIMP, BanisterTRIMP, StagnoTRIMP methods, respectively.

Table 1. Anthropometric and physiological characteristics of the subjects presented in mean and standard deviation values (±).

<table>
<thead>
<tr>
<th></th>
<th>Men (n = 4)</th>
<th>Women (n = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.8 ± 7.3</td>
<td>19.5 ± 2.1</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170 ± 10.7</td>
<td>162.5 ± 3.5</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>64.5 ± 18</td>
<td>55.1 ± 7.7</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>7.4 ± 5.6</td>
<td>15.2 ± 3.6</td>
</tr>
<tr>
<td>VO2max (mL.kg⁻¹.min⁻¹)</td>
<td>51.8 ± 6.9</td>
<td>41.9 ± 5.5</td>
</tr>
<tr>
<td>HRmax (bpm)</td>
<td>202 ± 3.4</td>
<td>192.5 ± 3.8</td>
</tr>
</tbody>
</table>

Table 2. Relationship of the TL estimations among the BanisterTRIMP, EdwardsTL, LuciaTRIMP, StagnoTRIMP and LacTRIMP methods.

<table>
<thead>
<tr>
<th></th>
<th>BanisterTRIMP</th>
<th>EdwardsTL</th>
<th>LuciaTRIMP</th>
<th>StagnoTRIMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>BanisterTRIMP</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>EdwardsTL</td>
<td>r = 0.88**</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>LuciaTRIMP</td>
<td>r = 0.61</td>
<td>r = 0.76*</td>
<td>-----</td>
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</tr>
<tr>
<td>StagnoTRIMP</td>
<td>r = 0.98**</td>
<td>r = 0.86**</td>
<td>r = 0.64</td>
<td>-----</td>
</tr>
<tr>
<td>LacTRIMP</td>
<td>r = 0.69</td>
<td>r = 0.86**</td>
<td>r = 0.91**</td>
<td>r = 0.67</td>
</tr>
</tbody>
</table>

DISCUSSION
The aim of this study was to correlate different methods of TL quantification based on the HR responses in the lactate blood concentration [La] and RPE. 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 BanisterTRIMP (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 BanisterTRIMP method is limited to evaluation of high intensity exercises, such as WT, high intensity interval training and plyometric training.

The BanisterTRIMP technique uses the mean HR of the session in its equation for quantification of training load, and its estimation is limited to high intensity intermittent exercises, since the HRmean for these exercise models does not represent the real intensity performed.

The session-RPE also presented strong correlation with the EdwardsTL method (r = 0.81), corroborating the findings by Impellizzeri et al. in men’s soccer (r = 0.54 – 0.78), and by Alexiou and Coutts in women’s soccer (r = 0.85). According to Borresen and Lambert, like the BanisterTRIMP 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 LuciaTRIMP method (r = 0.71) is similar to the correlation found by Impellizzeri et al. in men’s soccer (r = 0.61 – 0.85). Originally developed to quantify TL or the load relative to competitions in endurance modalities, LuciaTRIMP 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.

StagnoTRIMP has its equation based on the multiplication of a constant representative of the exponential increase of [La] in relation to the HRincrease 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.

Strong correlation was found between session-RPE and LacTRIMP (r = 0.91). Specially developed to quantify TL in team sports, LacTRIMP has its multiplication based on the addition of a constant representative of the exponential increase of [La] in relation to the HRincrease 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 LacTRIMP (r = 0.91), which demonstrated 82% of shared variation between methods. This correlation is higher.
than the one found by Alexiou and Coutts (r = 0.85) and Wallace et al.19 (r = 0.75) in women’s soccer and swimming, respectively. However, the \( \text{Lac}_{\text{TRIMP}} \) method requires relatively sophisticated equipment and expertise for the analyses. The fact it is an invasive procedure does not please the majority of the individuals18, and the constant training interruption for the blood collection procedure makes the application of the method proposed by Seiler and Kjerland difficult11. A possible explanation for this strong correlation is the remarkable contribution of the anaerobic metabolism during high intensity intermittent exercises16; 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-RPE16,17,19,22. 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 Coutts22, 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 studies22 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 of 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 athletes3. Although the present study had only evaluated one training session for each athlete, the results in the literature16,21,22 associated with the

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**Figure 1.** Relationship of the load quantification methods: (A) RPE of the session and EdwardsTL, (B) RPE of the session and LuciaTRIMP, (C) RPE of the session and LacTRIMP, (D) RPE of the session and BanisterTRIMP, (E) RPE of the session and StagnoTRIMP. All correlations were significant (P < 0.05).
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.

REFERENCES