Training load monitoring

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Chapter: Training Load Monitoring

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Training Load Monitoring

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Abstract

Actually, monitoring both training and competition loads have been identified as fundamental performance tracking indicators. For that reason, appropriate monitoring methods play an important role in the development of karate athletes' skills. In order to prescribe a specific training program aiming to develop, both aerobic and anaerobic metabolism, it is paramount to point out the methods usually used for the training load quantification. In this context, scientific evidences have shown that the subjective Rating of Perceived Exertion (RPE) can be considered both practical and easy measurement tool in comparison to others methods such as those based on heart rate measurement [i.e., training impulse (TRIMP)]. Thus, RPE can be implemented and systematically used for controlling karate training and competition load. The present chapter details the commonly used methods in the quantification of both training and competition load during specific karate kumite activities.

Introduction

Karate is one of the most practiced combat sport and martial art worldwide [1]. Studies focused on karate performance analysis have showed that this sport is composed by a repetitive short and intensive sequences of offensive and/or defensive actions intercepted with low intensity activities of stepping and turning in addition to referee breaks [2-7]. From a metabolic point of view, it was shown that karate kumite competition stresses both the aerobic and anaerobic energy systems [8]. For the aim to get the best performance, prescribing an optimal training load is needed based on the specificity of this martial art. In fact, training load monitoring is of tremendous importance since it makes coaches and scientific expert aware about whether the athlete is adapting adequately to certain level of exertion and provides, therefore, the opportunity for them to adjust training stimulus to optimize athlete's physical and physiological adaptations to exercise [9].

When monitoring the training load, the load's units can be thought of as either external or internal [10]. While the external load is defined as the work completed by the athlete, measured independently of his internal characteristics [10], the internal load is acknowledged as the physiological stress imposed to athlete and his ability to cope with it [11]. Although the external training load is one of the major factors for the quantification of internal training load, other factors such as level of pre-training conditioning and genetics significantly influence the training response. Thus, monitoring the process of physical training requires measurement of internal training load [12].For that reason, the present chapter aims to highlight the methods frequently used to quantify training load during specific karate kumite activities (i.e., training and competition).

Training Load Monitoring Methods

For the aim to choose an appropriate method to quantify training load, the coaching staff has to take into consideration the characteristics of the sport being monitored. Moreover, the choice of the best method for quantifying training load should be based on its ability to be applied for all training modalities (e.g., strength, speed, endurance and technical/tactical drills) [13]. Henceforth, this part will discuss the data from scientific literature focusing on training load monitoring tools.

Heart Rate-Based Methods

To enhance performance by adapting training regimen, the scientific literature reported many methods to quantify the training load based on the behavior of heart rate during the exercise session [14-22].

Among these methods, there are some based on the integrated analysis of the exercise time in different intensity categories defined according to individual physiological responses. For each category, an arbitrary coefficient of adjustment is assigned in order to give greater weight to training sessions at a higher intensity (i.e., training impulse) [14]. The training impulse (TRIMP) is often considered a useful and appropriate tool for assessing training load [15]. TRIMP is a unit of physical effort calculated in the basis of training duration, maximal, resting, and average heart rate during the exercise session [16].

The Banister Trimp Quantification Method

The first method, named Banisters' Training Impulse (Banister's TRIMP), is based on the heart rate responses, gradually weighted. It is calculated as the length of the session (in minutes) multiplied by an intensity factor which is differently defined for men and women [17].

The Banister's TRIMP weighs the duration using a weighting factor according to the following formula:

Banister's TRIMP $= D * (\text{factor A} * \Delta HR * \exp^{(\text{factor B} * \Delta HR)})$

Where - D = duration of training session in minutes

- For men: Factor A= 0.64 and Factor B= 1.92

- For women: Factor A = 0.86 and Factor B= 1.67

ΔHR ratio $= (HR_{ex} - HR_{rest}) / (HR_{max} - HR_{rest})$

In which: - HR_{ex} is average heart rate of the exercise session,

- HR_{rest} is resting heart rate

- HR_{max} is maximal heart rate.

This is a commonly recognized method which has been later developed By Morton et al. [16]. They gave greater weight to high-intensity training by adding number 'e' (2.718) in its calculation. **Morton's TRIMP** $= D * \Delta HR * 2.718\exp^{(\text{factor B} * \Delta HR)}$ In addition, another modification has been recently proposed which possibly overcome some limitations such as the comparison between continuous and interval training and considers pauses as well as the type of recovery [18].

The Edwards TL Quantification Method

The second method is commonly known as the Edwards' TRIMP or the summated heart rate zones' score method, originally introduced by Edwards [19], calculated as the product of the cumulated training duration (in minutes) for 5 heart rate zones multiplied by a coefficient relative to each zone (i.e., 50%-60% HR_{max} = 1; 60%-70% HR_{max} = 2; 70%-80% HR_{max} = 3; 80%-90% HR_{max} = 4; 90%-100% HR_{max} = 5).

The Edwards TL formula is as follow:

Edwards' TL = duration in zone 1 * 1 + duration in zone 2 * 2 + duration in zone 3 * 3 + duration in zone 4 * 4 + duration in zone 5 * 5

The Luciatrimp Quantification Method

Recently, a modified version of the summated heart rate zones equation has been introduced under the name "Lucia's TRIMP" [20].This method has been less stated and evaluated in the scientific literature and is based on individually determined lactate thresholds and the onset of blood lactate [La] accumulation. In this method, the duration spent in each of three heart rate zones (zone 1: below the ventilator threshold; zone 2: between the ventilator threshold and the respiratory compensation point and zone 3: above the respiratory compensation point) is multiplied by a coefficient (k) relative to each zone (k = 1 for zone 1, k = 2 for zone 2, and k = 3 for zone 3) and the adjusted scores are then summated.

The Lucia's TL formula is as follow:

Lucia's TRIMP = duration in zone 1 * 1 + duration in zone 2 * 2 + duration in zone 3 * 3

The Stagnotrimp Quantification Method

Stagno et al. [21] have developed a modified version of the Banister's TRIMP in an attempt to quantify training load based on the direct measurement of the athletes' [La] profile. The training load proposed by Stagno et al. [21] was calculated through the following formula:

Stango's TRIMP = $D * \Delta HR * 0.1225 * \exp^{(3.9434 \times \Delta HR)}$

The Lactrimp Quantification Method

According to Seiler and Kjerland [22], the training load is calculated through [La] concentration. Three intensity zones were adopted (zone 1: [La] ≤ 2, zone 2: 2 > [La] < 4, zone 3: [La] ≥ 4). A relative coefficient was attributed to each zone (k = 1, for zone 1; k = 2, for zone 2; and k = 3, for zone 3). The LacTRIMP was calculated by the sum of the multiplications of the times spent in the different zones by the coefficient relative to each zone.

Even if heart rate based methods have been used to quantify the load of different training sessions, according to Foster et al. [23], these methods present some limitations. First, despite the availability of monitors capable of integrating the heart rate responses to exercise for long periods, its use is restricted due to economic factors. Moreover, any technical problems presented by the monitor could compromise the information obtained in the session. In combat sports, such as karate the use of heart rate -based methods have been considered a relatively poor method of evaluating high intensity exercise e.g., high intensity interval training and plyometric training (these types of exercises depend on a large contribution from oxygen independent metabolism rather than oxygen-dependent mechanisms) [23].Most of these exercises are commonly prescribed by coaches within karate kumite practitioners. Also, the use of the monitors may pose a risk to the practitioner's physical integrity in addition to the possible equipment damage [24]. In conclusion, heart rate based methods are considered as an important tool to quantify training load; nevertheless this method cannot be applied to all modalities of training such as sessions training in karate (i.e., sparring drills).

Session Rating of Perceived Exertion

In response to the limitations for using heart rate based methods to quantify training load, Foster et al. [23,25] developed a method intended to circumvent the problems based on the association with heart rate measures during training sessions and competition. This method, named the session Rating of Perceived Exertion, is calculated by multiplying the relative subjective perceived exertion (RPE) of the session by the duration of the exercise (in minutes), or the number of repetitions for resistance training [26].

The Rating of Perceived Exertion (RPE) is a measurement tool used by coaches and athletes to quantify training load and monitor athlete's adaptation to training process. The most common used tool to assess the RPE is the Borg scale [6–20] (Table 1) Category followed by the modified Borg Category-Ratio-10 scale (CR-10) (Table 2) [23]. Studies have shown that the session RPE is a valid and reliable measure for quantifying the intensity of the whole training for both steady-state [23,27] and intermittent exercises [23,11]. The RPE has been reported to be correlated with many physiological markers of exercise intensity such as oxygen consumption (VO2), ventilation, respiratory rate, [La] concentration, and heart rate during a variety of exercise protocols [28].

Furthermore, it was suggested that the RPE value is a psychophysiological integrator [26]. Scientific data corroborated the evidence that RPE can be used to estimate maximal oxygen consumption (VO2max) or the maximal rate of work from graded exercise tests [29] and from the 20-m shuttle run test [30]. Likewise, it was shown that RPE is efficient to predict maximal performance of intermittent vertical jump [31]. From another perspective,the critical power calculation findings denoted the reliable use of RPE [32].

Thus, RPE has been considered as a simple and valid tool for quantifying the whole training session intensity in high-level intermittent exercise, [33,34], speed, and plyometric training in both young and adults athletes [11]. It should be noted that TL by using RPE is measured in Arbitrary Units (AU).

Training Load = Session RPE x Duration (minutes)

Rating	Descriptor
6	-
7	Very, very light
8	-
9	Very light
10	-
11	Fairly light
12	-
13	Somewhat hard
14	-
15	Hard
16	-
17	Very hard
18	-
19	Very, very hard
20	-

Table 1: Borg's RPE-Scale (6–20) proposed by Borg [35].

Rating	Descriptor
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	-
7	Very hard
8	-
9	-
10	Maximal

Table 2: The modified CR-10 RPE Scale proposed by Foster et al. [22].

Training Load Quantification in Karate Training and Competition

The RPE was frequently used in numerous investigations related to the practice of karate [36-41]. Imamura et al., [36] assessed the perceptive responses of highly skilled and novices male karate practitioners after performing 1.000 punches and 1.000 kicks. The findings relative to the RPE scores obtained immediately after 1.000 punches from highly skilled and novices were 12.2±1.2 and 12.8±1.2, respectively. With regard to 1.000 kicks execution, RPE scores recorded were 14.2±1.2 and 16.3±1.5 for skilled and novices athletes, respectively. While, the given RPE scores by coaches (14.8±1.8 and 16.7±1.7 after 1.000 punches and 1.000 kicks, respectively) were significantly higher than that obtained from athletes. This study allows coaches to adjust the intensity of the work to reach the targeted score. In another study, Imamaura et al., [37] found that the RPE scores were 11.3±0.8 and 15.7±1.0 (1.000 punches and 1.000 kicks, respectively) within six female black belt practitioners. The scores collected suggested that performing 1.000 punches and 1.000 kicks can be rated as light and hard, respectively [42].

Recently, Milanez et al., [38] studied the relationship between the whole RPE exercise session (RPE-S) and physiological markers of exercise intensity during a karate training session. In this study, eight well-trained karate athletes performed a single training session involving basic karate techniques and sparring. The RPE was taken each 10-min during exercise using the Borg's 6-20 scale. In addition, the modified CR-10 scale 30-min was used to quantify the exercise after a 30min of its end. The results proved a significant relationships ($p< 0.05$) between RPE-S and mean [La] concentration ($r = 0.96$), %HRmax ($r = 0.91$), %HRres ($r = 0.87$) and RPE ($r = 0.78$) during the session (figure 1), while, there was no significant association between RPE-S and the duration of exercise bout ($r = -0.28$, $p> 0.05$). Moreover, Milanez et al., [39] calculated the Banister TRIMP, EdwardsTL, Lucia TRIMP, Stagno TRIMP and Lac TRIMP during karate training session within eight Shotokan karate athletes, of both sexes, aiming to study their association with the session RPE. The Results highlighted a significant correlations ($p<0.05$) between session-RPE and BanisterTRIMP ($r = 0.79$), EdwardTL ($r = 0.81$), LuciaTRIMP ($r = 0.71$), StagnoTRIMP ($r = 0.71$) and LacTRIMP ($r = 0.91$). 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. Thus, the results of this study suggest that the session-RPE can be considered as an efficient and valid method to quantify training load in shotokan karate training activities [40].

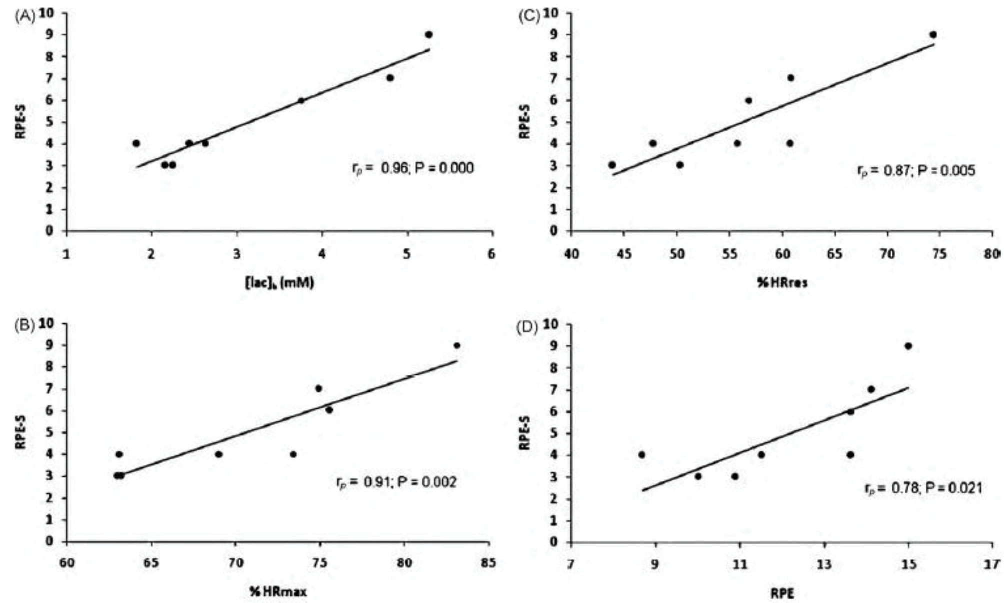

Figure 1: Relationships between session-RPE (RPE-S) and physiological parameters measured during the training session, including. A. Blood lactate ([lac]b). B. Percentage of maximal heart rate (%HRmax). C. Percentage of heart rate reserve (%HRres). D. Rate of perceived exertion (RPE) [Adapted from the study of Milanez et al., (38)].

Regarding the perceptive responses among young karate athletes, Padulo et al., [41] used the Foster's RPE-based approach to quantify internal training load during training sessions (i.e., 5 consecutive days with two training sessions per-day) within eleven young karate practitioners. The main findings of the study showed a significant ($p < 0.001$) correlations between RPE and The two objective methods (i.e., Edwards and Banisters TRIMP methods) based on the HR response to exercise. The correlation coefficient (r) values recorded were from 0.84 to 0.92 and 0.84 to 0.97 for EdwardTL and BanisterTRIMP, respectively. Thus, it was confirmed that session-RPE can be used as a valid alternative for quantifying training loads during karate specific physical training and technical /tactical drills within young practitioners.

Similarly to its use during training programs, the RPE was used also for quantifying karate competition's load. Recently, Tabben et al., [40,42] proved a significant correlation between RPE and some physiological markers such as resting HR ($r = 0.60$; $p=0.004$), mean HR($r = 0.64$; $p=0.02$) and [La] ($r = 0.81$; $p<0.001$). According to the same study, the authors assessed the relationship between the subjective method (session-RPE) and 2 objectives heart rate based methods. They showed large correlations between the session-RPE and heart rate -based methods (r=84 and r=0.95 for Banister's TRIMP and Edwards TL, respectively) P [figure 2]. The magnitude of correlations between session-RPE method and the heart rate based methods were in accordance with the study of Haddad et al., [43] conducted within Taekwondo practitioners (i.e. Banister's TRIMP, r values ranged from 0.56 to 0.90; Edwards TL, r values ranged from 0.55 to 0.86). Authors concluded that session-RPE is a valid method for quantifying internal load and intensity in karate kumite competition.

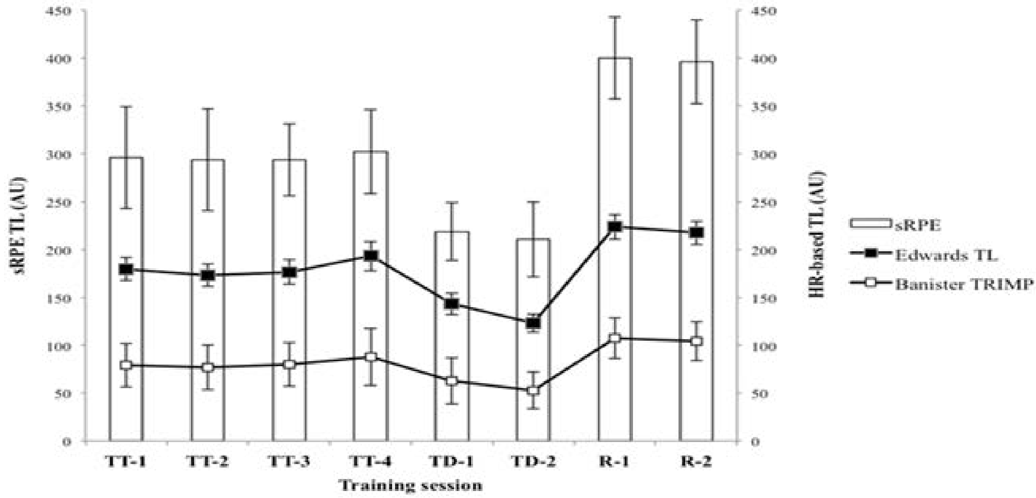

Figure 2: Mean ± standard deviation of the internal training load (session-RPE method: sRPE; Banister's training impulse method: TRIMP; Edwards's training load method: TL) of elite karate athletes in different karate training session modes [tactical-technical: TT-S, technical-development: TD-S and randori: R-S) (Adapted from the study of Tabben et al., (40].

Conclusion

Coaches and sport scientists should emphasize an optimal amount of physical training to improve physical fitness towards achieving the best performance. Literature analysis highlighted a variety of methods to assess the individual athlete's training load during both training and competition. It was proved that the session-RPE is a valid and reliable approach for quantifying internal training load as HR-based methods among adult and young athletes. The attraction of this method lies in the fact that it provides together an easy and good alternative with a low cost to monitor different specific karate activities. Henceforth, the session-RPE is a workload monitoring techniques that should be systematically implemented during the load quantification of karate kumite training and competition

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