Sports Science

Are rating of perceived exertion and heart rate methods useful to monitor the internal training load in functional training?

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Abstract - Aim: The study aimed to quantify and characterize the Training Load (TL) in a Functional Training (FT) model using Heart Rate (HR) and Session Rating of Perceived Exertion (sRPE) methods, and to verify whether these methods could be valid to monitor the TL during a FT program. **Methods:** The study design consisted of two phases: *phase 1* - composed of a single training session of FT ($FT_{SESSION}$), in which HR, sRPE, and pre- and post-exercise lactate [La] levels were assessed; *phase 2* - composed of a FT program ($FT_{PROGRAM}$) with eight weeks of duration and two sessions per week. The HR and $_{S}$RPE were utilized to monitor all training sessions, and the results between sessions 1 vs. 8, 8 vs. 9, and 9 vs. 16 were compared. **Results:** On *phase 1*, HR distribution demonstrated that the participants spent about 75% of the total training time above 80% HR_{max}. Post-exercise [La] values were significantly higher ($p < 0.05$) than pre-exercise. The mean sRPE score was 8.5 ± 1.2. In *phase 2*, HR distribution was different between sessions 1-8 and 8-9 ($p < 0.05$). A strong correlation ($r = 0.790$) between the internal training load (ITL) and Training impulse (TRIMP) was observed. **Conclusion:** Our data demonstrated that the $FT_{SESSION}$ can be characterized as a high-intensity exercise, based on the pattern of HR responses and sRPE, and was reinforced by the [La_{peak}]. Also, the TL monitoring methods (sRPE and TRIMP) proved to be valid for monitoring FT programs.

Keywords: workload, training load, circuit training, body weight-based exercise, heart rate.

Introduction

Functional training (FT) is described as a set of exercises that aim to improve strength, balance, flexibility, and coordination through integrated and multiplanar movements[1,2]. FT is also known as multicomponent training, task-specific training, circuit training, and body weight-based exercise, among other nominations. FT incorporates different types of exercise (i.e., resistance, aerobic, balance, cognitive) in a synergistic, integrated, and balanced manner [1]. These dynamic characteristics, inexpensiveness, and flexibility-can be performed indoors or out-contribute to its popularity[3-6]. This makes FT one of the top twenty global fitness trends since 2007[2]. However, this multicomponent particularity factor can make it difficult to characterize and monitor the training load (TL) during FT programs.

TL can be assessed using external training load (ETL) and internal training load (ITL) markers. The ETL is an objective measure of the workload performed during a given training session related to volume and intensity variables; ITL is the acute physiological response induced by exercise[7]. TL monitoring methods vary considerably depending on the sport or activity. Nevertheless, TL monitoring is often assessed using heart rate (HR) based methods such as training impulse (TRIMP)-a product of intensity and volume factors-or evaluated based on the HR distribution in intensity effort zones[8]. Ratings of perceived exertion (sRPE)[9] are used as the primary measure of ITL[10]. Moreover, subjective measures such as sRPE can be more sensitive than objective measures[11], and sRPE is the most assessed TL variable over a variety of sports[12].

Traditionally, exercise intensity is determined by HR, sRPE, oxygen uptake, ventilatory threshold, or blood lactate concentration ranges. Exercise is classified into low, moderate, or high-intensity zones using these ranges[13,14]. However, these parameters are habitually established by performing a maximal effort test, considering the specificity of the type of exercise[13,14]. Due to the multicomponent characteristic of FT, there are no specific methods or maximal effort tests for FT programs when combining various exercises. This makes TL characterization and monitoring challenging. It has been proposed that the TL could be divided into low, moderate, and high-intensity zones using certain TL methods and intensity parameters. This approach has been validated and is useful for various sports[15,16−18]. Based on psychophysical constructs, the sRPE method provides a global indicator of exercise intensity, enabling an accurate measure of an individual's response to a training dose[15]. Organizing the training intensity continuum into specific zones is common in exercise models and sports studies[18]. For instance, Lovell et al.[15] and Moreira et al.[16] demonstrated the validity and the usefulness of the sRPE in their respective studies with rugby players. They examined training intensity zones without performing maximal effort tests.

Using non-experimental data, Teixeira et al.[5] and Machado et al.[6] indicated that TL monitoring in FT could be done using traditional methods, such as HR and sRPE, as previously described. Machado et al.[6] also suggest that the lactate concentrations ([La]) could be used to analyze exercise intensity. Studies that utilized the FT as an intervention program have adopted both HR and effort perception methods[19-21]. None of the studies tested or reported on the validity of these methods for TL characterization or monitoring.

Considering the lack of information on TL variables in the FT model, the present study aimed to quantify and characterize the TL in an FT model using HR[8] and sRPE based methods[9]. We aimed to verify the validity of these methods for monitoring TL during an FT program. It is hypothesized that FT could be characterized as a high-intensity exercise and that HR and sRPE based methods are valid for monitoring TL during the FT program.

Materials and methods

Participants

The sample was composed of fifteen cisgender participants (ten women and five men) with mean age of 26.2 ± 4.0 years. A total of thirteen (eight women and five men), with mean body mass (kg) 68.3 ± 13.4, height (m) 1.6 ± 0.1, and Fat% 26.9 ± 7.7, participated in the $FT_{SESSION}$, and ten (eight women and two men) with mean body mass (kg) 62.0 ± 11.0, height (m) 1.64 ± 0.1 and Fat % 25.3 ± 6.4 participated of the $FT_{PROGRAM}$. Seven participants performed the two phases of this study.

The physical activity level of the participants was determined by International Physical Activity Questionnaire (IPAQ). Only one participant was characterized as "Active". The other participants were characterized as "Irregularly Active A" or "B". Thus, the participant group was considered irregularly active.

The inclusion criteria adopted were to be able to perform the exercise routine; do not use any medications that influence the HR responses (stimulants or blockers); do not present any cardiac disease (according to anamnesis and cardiological test before experimental procedures); age between 18 and 35 years. Participants who did not complete the $FT_{SESSION}$ in two trials after reporting dizziness and nausea (1 participant) and who started another training program during the $FT_{PROGRAM}$ (1 participant) were excluded. Thus, 12 individuals in $FT_{SESSION}$ and 9 in $FT_{PROGRAM}$ completed the study.

All participants were informed about the research procedures and signed the consent form. The procedures carried out following the regulations required in the Resolution 466/2012 of the National Health Council on research involving human beings and this project was approved by the local University Ethics Committee, under the protocol number 2.395.616/2017.

Study design

The current study consisted of two phases: *phase 1* - composed by a single training session of FT ($FT_{SESSION}$), in which HR, sRPE, and pre-and post-exercise [La] were assessed; *phase 2* - composed of a FT program ($FT_{PROGRAM}$) with eight weeks of duration and two sessions per week. For training monitoring, HR and $_{S}$RPE were analyzed in all 16 sessions.

All participants performed a familiarization session one week before the experimental protocol. The familiarization was performed with reduced volume (10 min of duration) and intensity (20 s of exercise for 40 s of passive recovery) compared to the original protocol. The focus of the familiarization was the execution of the exercises.

For *phase 1*, data were collected on four consecutive days in the same week, from 8:00 a.m. to 10:00 a.m. All participants performed the $FT_{SESSION}$ only once and started the circuit performing the same exercise routine. In addition to HR and sRPE monitoring, blood samples were collected pre- and post-the exercise sessions for [La] analysis.

In *Phase 2*, the training sessions were carried out in the morning (8:00-8:30 a. m) and in the afternoon (5:30-6:00 p.m.), two times a week. Participants chose the training schedule according to their time and performed all sessions at the same daytime of their choice. The HR and sRPE responses were monitored in all 16 sessions.

FT protocols

Exercises were chosen based on the FT description, which suggest the integration of physical capacities (i.e., muscular endurance, cardiorespiratory resistance, balance, agility)[1,22,23]. Different exercise protocols were used, composed of 10 exercises of calisthenics, multiarticular and monoarticular characteristics, arranged in circuit.

The $FT_{SESSION}$ and sessions 1-8 of the $FT_{PROGRAM}$ were performed following the same exercise protocol (protocol 1: squat; lunge; hip thrusts; burpee for beginners variation - bench squat thrust; jumping jack; jump over-step; push-up; TRX row; sit-up and oblique sit-up). From sessions 9-16 of the $FT_{PROGRAM}$, the exercises complexity that comprised the initial training protocol was increased for TL progression, as proposed by Teixeira et al[1] (protocol 2: squat + lunge; walking lunge; hip thrusts on Swiss ball; sumo squat on agility ladder; burpee; high knees on jump trampoline; push-up; TRX row at a 90-degree angle; sit-up and plank).

The training sessions were characterized by two rounds, alternating 1 min of exercise for 30 s of passive recovery (2: 1), totaling 30 min.

Training load

The HR was monitored beat-to-beat using a Polar Team 2 Pro (Polar®, Kempele, Finland) in the $FT_{SESSION}$ and a Polar Watch RS800CX (Polar®, Kempele, Finland) in the $FT_{PROGRAM}$. The HR data obtained in the two phases were exported and analyzed using Polar Pro Trainer 5 software (Polar®, Kempele, Finland). HR responses were distributed in intensity zones (zone 1: 50-60%; zone 2: > 60-70%; zone 3: > 70-80%; zone 4: > 80-90%; zone 5: > 90%), represented by a percentage range of maximal HR (HR_{max})[8]. Training impulse (TRIMP) was calculated by the time (minutes) accumulated in each intensity zone and multiplied by the respective arbitrary value of the same zone[8].

The HR_{max} was considered the maximum value of HR reached during the $FT_{SESSION}$ (sHR_{max}). For the $FT_{PROGRAM}$, the sHR_{max} achieved in the 1st session of each protocol was considered. sHR_{max} verified in session 1 was used from session 1 to 8 and sHR_{max} verified in session 9, from session 9-16. For comparison, the HR_{max} estimated from the equation proposed by Tanaka[24] (eHR_{max}) was also calculated.

The $_{S}$RPE was monitored using an adapted scale of 10 points (CR-10) proposed by Foster[9], 15 minutes after the end of the session[25]. For the estimated internal training load (ITL), the $_{S}$RPE score was multiplied by the duration (in minutes) of the training session. TRIMP and $_{S}$RPE results were presented in arbitrary unity (AU).

Blood samples (25 μL) were collected from the earlobe to determine the lactate concentration ([La]) at the pre-moment ($[La_{pre}]$), immediately after the session ($[La_{post}]$), at the 3rd ($[La_{min3}]$) and 5th ($[La_{min5}]$) minutes after the end of the session, by a heparinized capillary tube and immediately transferred to Eppendorf® tubes containing 50 μL of 1% sodium fluoride (NaF) and frozen at −20 °C for further analysis. Lactate concentration was determined electrochemically on a YSI 2300 STAT® (Yellow Springs Ind, Ohio, USA). Lactate peak ($[La_{peak}]$) was defined for each participant as the highest post-exercise [La] value.

Statistics analysis

All analyses were performed on Graph Pad Prism (version 9), considering a significance level of 5% ($p < 0.05$). The normality of the data was verified by the Shapiro-Wilk test and the descriptive data were presented as mean ± standard deviation (SD). After, the *t*-test for independent samples was performed for the comparison between the HR_{max} values reached in the $FT_{SESSION}$ and the HR estimation by the Tanaka equation.

One-way ANOVAs with Bonferroni *post-hoc* test was performed to verify the variances between time-points for the HR distribution in intensity zones related to HR_{max} in $FT_{SESSION}$, the [La] at pre-and post-$FT_{SESSION}$. Also, the same test was performed to compare sRPE, ITL, and TRIMP 1-8, 8-9, and 9-16 sessions during the $FT_{PROFGRAM}$.

The HR distribution in intensity effort zones on sessions 1-8, 8-9, and 9-16 were evaluated by two-way ANOVA test (zones and sessions) considering the assumptions of homogeneity of the variances (*Levene's test*) and equality of matrices of covariance (Box M test) followed by *Bonferroni's post hoc*, considering the significance of the test ($p < 0.05$).

The correlation between Time Z5 and $[La_{peak}]$ in the $FT_{SESSION}$ was performed using Pearson test. The Pearson test was also used to correlate sRPE, ITL, Time Z5 and $[La_{peak}]$ on the $FT_{PROGRAM}$. For TRIMP correlate with variables presented in Table 2, was used the Spearman test. The adopted qualitative description was proposed by Hopkins[26].

Results

$FT_{SESSION}$

The mean HR values for immediately before $FT_{SESSION}$ (HR_{pre}), as well as the HR_{max} during the $FT_{SESSION}$ and the HR_{max} estimated by Tanaka's equation[24] were 80 ± 12 bpm, 185 ± 13 bpm, and 189 ± 3 bpm, respectively. There was no difference between the HR_{max} verified in the and $FT_{SESSION}$ and the HR_{max} estimated by Tanaka et al. (2001) ($p = 0.365$; $t = 0.924$; $df = 22$). The average HR found during $FT_{SESSION}$ was 158 ± 15 bpm, which corresponds to 84.9% of the HR_{max}.

Figure 1 shows the pattern of HR distribution in zones related to HR_{max} and includes both exercise time and passive rest time. The participants spent about 95% of the total training time in zones 3, 4, and 5, with the highest percentages found for zones 4 (42.8 ± 7.7%) and 5 (32.5 ± 14.3%). The activity in zones 3, 4, and 5 was different from zones 1 and 2 $p < 0.001$, for the three intensity zones). Zones 4 and 5 also presented differences compared to zone 3 ($p < 0.001$, $p = 0.005$, respectively). There was no difference between zones 4 and 5 ($p = 0.112$).

The mean values for the sRPE, ITL, and TRIMP related to the $FT_{SESSION}$ were 8.5 ± 1.2 (AU), 250.0 ± 46.9 (AU), and 121.3 ± 13.0 (AU), respectively. Individual values were presented in Figure 2.

Table 1 shows the pre-and post-[La] concentrations for $FT_{SESSION}$. The largest difference found at the end of $FT_{SESSION}$, is described as $[La_{peak}]$. Among the twelve participants, eight individuals presented the highest blood lactate concentrations at $[La_{post}]$, three at $[La_{min3}]$ and only one individual at $[La_{min5}]$. All post-exercise [La] values were higher than the pre-exercise values ($p < 0.001$; $F = 167$). There was no difference between $[La_{post}]$, $[La_{min3}]$, $[La_{min5}]$, and $[La_{peak}]$. A very strong correlation[26] was observed between $[La_{peak}]$ and the time spent in zone 5 (Time Z5) ($r = 0.765$; $p < 0.001$).

Table 2 presents the correlation between TL monitoring methods and total time spent (in minutes) in zone 5 (Time Z5) and $[La_{peak}]$.

Table 1 - Blood lactate concentrations pre- and post-$FT_{SESSION}$ ($n = 12$).

$[La_{pre}]$ ($mmol{\cdot}L^{-1}$)	1.8 ± 0.6
$[La_{post}]$ ($mmol{\cdot}L^{-1}$)	13.0 ± 2.7*
$[La_{min3}]$ ($mmol{\cdot}L^{-1}$)	12.8 ± 2.8*
$[La_{min5}]$ ($mmol{\cdot}L^{-1}$)	12.1 ± 2.7*
$[La_{peak}]$ ($mmol{\cdot}L^{-1}$)	13.3 ± 2.9*

Note: Blood lactate concentration at pre-exercise ($[La_{pre}]$); Blood lactate concentration immediately post the exercise session ($[La_{post}]$); Blood lactate concentration at the 3rd minute after the end of the session ($[La_{min3}]$); Blood lactate concentration at the 5th minute after the end of the session ($[La_{min5}]$); The largest difference found in the end of $FT_{SESSION}$ ($[La_{peak}]$).

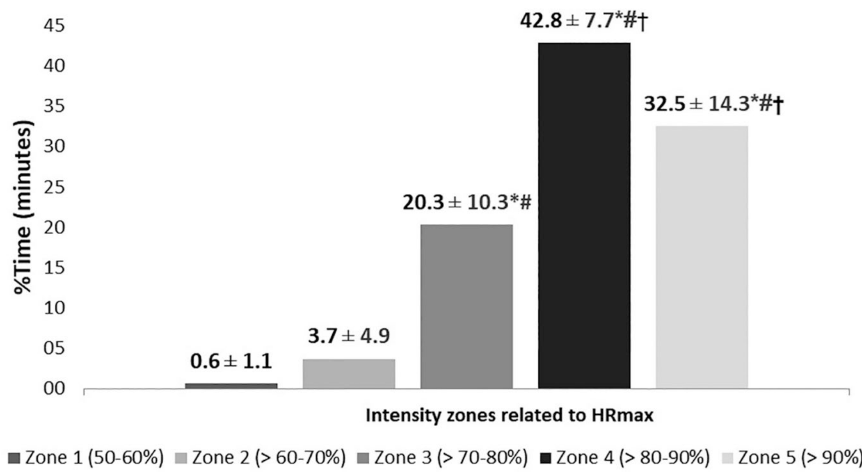

Figure 1 - Time percentage spent in intensities effort zones relative to HR_{max}, during the TF session ($n = 12$). $F = 48.6$. *$p < 0.05$ in relation to zone 1; #$p < 0.05$ in relation to zone 2; †$p < 0.05$ in relation to zone 3.

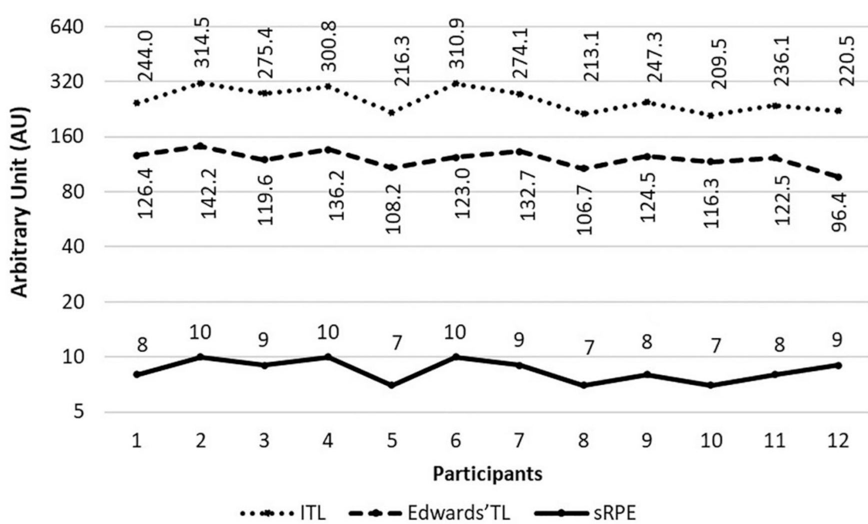

Figure 2 - Individual sRPE, ITL and TRIMP quantification in the $FT_{SESSION}$.

Table 2 - Correlations between training load monitoring methods based on the HR and RPE with the analyzed variables in the $FT_{SESSION}$.

	sRPE (AU)		ITL (AU)		TRIMP (AU)	
	r	p	r	p	r	p
Time Z5 (min)	0.566*	0.055	0.597*	0.040	0.944***	0.000
$[La_{peak}]$ ($mmol \cdot L^{-1}$)	0.619*	0.032	0.367*	0.241	0.825**	0.001
sRPE (AU)	—	—	0.725**	0.008	0.605*	0.037
ITL (AU)	0.725**	0.008	—	—	0.790**	0.002
TRIMP (AU)	0.605*	0.037	0.790**	0.002	—	—

Note: Total time spent in zone 5 (Time z5); The largest difference found in the end of $FT_{SESSION}$ ($[La_{peak}]$); Rating of perceived exertion of the session (sRPE); internal training load by sRPE (ITL); Training impulse by Edwards[8] (TRIMP); AU, arbitrary unit.
*Strong correlation.
**Very strong correlation.
***Near-perfect correlation[26].

$FT_{PROGRAM}$

Figure 3 presents the time percentage spent in intensity effort zones related to HR_{max} during all 16 sessions. A significant interaction effect between zones and sessions ($p < 0.001$; $F = 8.488$) was observed. The *post hoc* test shows a significant decrease in the percentage of time spent in zone 5, between the 1st (session 1) and the last session (session 8) of protocol 1 ($p = 0.008$). There was a significant increase in the time spent in the same zone ($p = 0.002$) when the last session of protocol 1 (session 8) was compared with the 1st session of protocol 2 (session 9). Consequently, the time spent between the lower intensity zones, such as zone 2, showed a significant increase when compared to sessions 1 and 8 ($p = 0.014$), and a significant decrease for sessions 8 and 9 ($p = 0.004$). There was no statistical difference for zone 3, when comparing sessions 1 and 8 ($p = 0.191$) and sessions 8 and 9 ($p = 0.096$). The distribution of HR between zones 1 and 4 did not present a statistical difference for the analyzed sessions.

The mean values of ITL, TRIMP, and sRPE verified in all $FT_{PROGRAM}$ sessions are presented in Figure 4. All monitoring methods presented significant difference between sessions 1 vs. 8 ($p = 0.022$ for ITL; $p = 0.033$ for TRIMP and $p = 0.020$ for sRPE) and between sessions 8 vs. 9 ($p = 0.022$ for ITL; $p = 0.001$ for TRIMP and $p = 0.025$ for sRPE). There was no significant difference between sessions 9 vs. 16 for all monitoring methods. Moreover, a very strong correlation ($r = 0.790$; $p < 0.002$) was found between the ITL and TRIMP methods.

Discussion

This study was composed of two phases. *Phase 1* aimed to quantify and characterize the TL in an FT model using HR[8] and sRPE methods[9]. *Phase 2* aimed to verify the validity of these methods for TL monitoring during an FT program. The main findings demonstrated that the $FT_{SESSION}$ could be characterized as a high-intensity exercise, according to HR distribution and sRPE scores. The observed post-exercise [La] results validate this characterization. Also, the TL quantification methods were validated for TL monitoring during the FT program, confirming the present study's hypothesis. To our knowledge, this is the first study to quantify and describe TL using HR and sRPE methods, both in a single FT session and across an FT program.

The HR distribution in the intensities effort zones showed that participants spent most of the total training time (≅ 75%) between the most intense zones (4 and 5, i. e. above 80% HR_{max}). This indicates that the $FT_{SESSION}$ was performed at high intensity, per the classification pro-

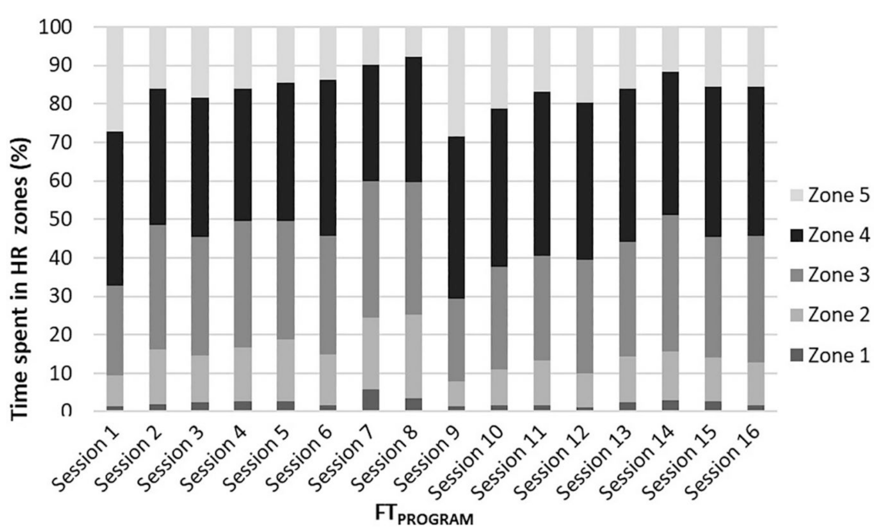

Figure 3 - HR distribution in intensity effort zones (zone 1: 50-60% HR_{max}; zone 2: > 60-70% HR_{max}, zone 3: > 70-80% HR_{max}; zone 4: > 80-90% HR_{max}; zone 5: > 90% HR_{max}) during all sessions of the $FT_{PROGRAM}$ ($n = 9$). ($F = 8.488$).

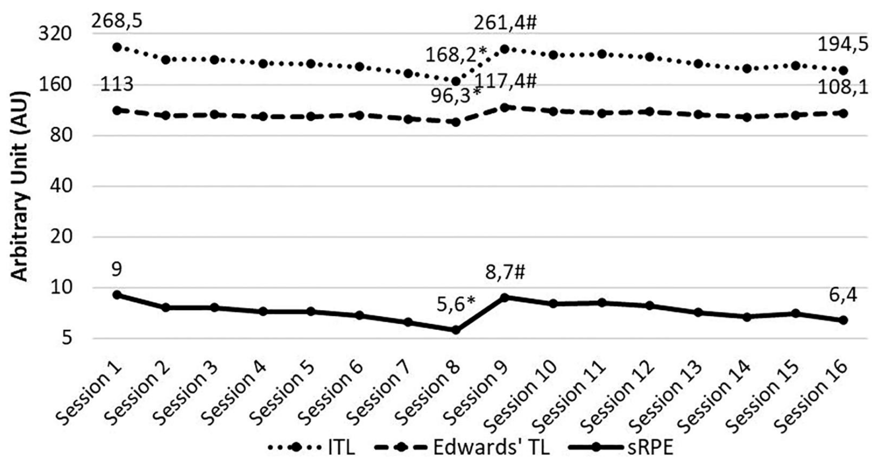

Figure 4 - Mean values of ITL, TRIMP and sRPE verified in $FT_{PROGRAM}$ sessions. ITL (F = 8.906), TRIMP (F = 12.08) and sRPE (F = 8.874) $FT_{PROGRAM}$ sessions. $*p < 0.05$ session 1. $\#p < 0.05$ session 8.

posed by the ACSM[13] and other authors in different sports[15-18]. In addition, it is important to note that the% HR_{max} average between participants was 84.9 ± 3. Furthermore, the HR responses include both exercise time and passive rest.

Despite the reports from studies that have used HR responses to describe TL in FT sessions[19-21,27], none have demonstrated HR responses distributed over intensity effort zones[8], limiting the comparison. However, when comparing the mean%HR_{max} in the FT session, the values were very similar (84.9 ± 3% vs. 84.6 ± 5.3%) to the calisthenic exercise protocol with a similar volume (23 min-36.5 min)[19].

Compared to CrossFit® protocols-High-Intensity Functional Training (HIFT)-the $FT_{SESSION}$%HR_{max} average was lower than the values reported for both short HIFT (84.9 ± 3% vs. 92.7 ± 4%) and long HIFT (84.9 ± 3% vs. 91.3 ± 3%)[21,27]. The characteristics of the HIFT protocols may explain these lower HR responses observed in the present study. First, CrossFit® protocols are considered the most intense FT models[28]. Both HIFT protocols were performed utilizing weights and other equipment (e.g., dumbbells, kettlebells, rowing ergometer, Olympic barbell), and the total volume of the HIFT was at least two times lower than the $FT_{SESSION}$ (30 min vs. > 2 min for short HIFT; 15 min for long HIFT). Yet, the HIFT exercises were performed "all-out"[6] with rest *ad libitum*. In contrast, all $FT_{SESSION}$ exercises had calisthenic characteristics and were performed in a fixed time with passive rest (2:1 proportion). According to Abderrahman et al. (2013)[29], passive rest or recovery could make HR maintenance during intermittent exercise difficult.

The mean sRPE score (8.5 ± 1.2) was between "extremely hard" (score 8) and "almost maximum" (score 9) intensity classification, as proposed by Seiler and Kjerland[18]. This indicates that the $FT_{SESSION}$ was performed in the high-intensity zone. Compared to other calisthenics protocols performed at high intensity, the $FT_{SESSION}$ sRPE score was higher (8.5 ± 1.2 vs. 7.3 ± 1.3 and 8.5 ± 1.2 vs. 7.5 ± 1.0)[19,20]. In addition to HR responses and sRPE, the [La] found after the $FT_{SESSION}$ supports the intensity characterization; the mean observed value of [La_{peak}] indicates the significant contribution of the anaerobic glycolytic metabolism[30]. All [La] values verified post-exercise were higher than the secondary criterion concentration used to indicate effort made until maximal voluntary exhaustion (i.e., ≥ 8 $mmol \cdot L^{-1}$)[31]. Similar concentrations are generally found in high-intensity protocols, such as maximum tests performed on a treadmill (10.3 ± 2.0 $mmol \cdot L^{-1}$)[32] and during HIFT (long: 13.7 ± 1.5 $mmol \cdot L^{-1}$; short: 14.2 ± 2.0 $mmol \cdot L^{-1}$)[21,27].

For comparison, the post-exercise [La] values of the calisthenic protocol proposed by Gist et al.[19] were lower than the $FT_{SESSION}$ (11.1 ± 2.9 $mmol \cdot L^{-1}$ vs. 13.3 ± 2.9 $mmol \cdot L^{-1}$). According to Buchheit and Laursen[30], the proportion of 2:1 for effort:pause-ratio increases anaerobic glycolytic energy demand, which can increase blood lactate levels at the end of the exercise.

The correlations between sRPE [La_{peak}], ITL, and TRIMP suggest that the sRPE method can be used as a practical and effective method for quantifying TL in the FT model[33]. These findings highlight the broad scope of the RPE scale and endorse it as a method of TL quantification in a variety of exercise models and sports[15,16,18,33,34]. In addition, the sRPE and TRIMP also positively correlated with the [La_{peak}] and each other. This indicates that they may represent the magnitude of the stress suffered due to physical effort. These results were expected because these methods are used in intermittent exercise models and sports modalities following these characteristics[15,16,35,36]. Moreover, the positive correlation found between Time Z5 and [La_{peak}] demonstrates the influence of exercise intensity on lactate responses. This implies it is a good marker for metabolic stress analysis in this FT model.

The second phase of this study was characterized by TL monitoring during the eight weeks of the $FT_{PROGRAM}$. The HR distribution, sRPE, ITL, and TRIMP were verified in all 16 sessions. The results of sessions 1 vs. 8, 8 vs. 9, and 9 vs. 16 were compared to analyze the sensitivity of the training adaptation monitoring methods[13] and load progression[1]. The HR responses, sRPE, ITL, and TRIMP variations verified between sessions with the same protocols (sessions 1 vs. 8) and in the transition from protocol 1 to 2 (sessions 8 vs. 9, respectively), provided evidence for the validity of the monitoring methods for TL changes during the $FT_{PROGRAM}$.

These results indicate the validity of these monitoring methods for assessing training load during an FT program[37,38]. The results are considered in conjunction with the cardiovascular and psychophysiological responses from the FT. The ITL and TRIMP results showed a similar pattern at a different magnitude. This suggests the importance of using both methods to monitor FT to obtain more comprehensive information on the participants' psychophysiological responses. This provides a more robust monitoring training system that may aid in the optimization of the individual prescription. This could ensure better training program results. Notably, the correlation observed in the present study supports results observed in other studies[34-36,38,39]. Our study, therefore, adds important information to existing literature, specifically regarding FT monitoring.

Conclusion

The present study demonstrated that the assessed $FT_{SESSION}$ can be characterized as a high-intensity exercise, based on the pattern of HR and sRPE responses, and reinforced by the [La_{peak}]. Finally, the TL monitoring methods (sRPE and TRIMP) proved to be valid to be used during FT programs. Such information may serve as a basis for prescription and TL monitoring in similar FT programs while assisting professionals, students, and researchers concerning with this activity to better monitor the FT intervention programs. However, the study present limitations, such as the small number of participants in the $FT_{PROGRAM}$, not controlling the sleep time and the environment temperature of the training local and lacking to monitor other training responses associated with the imposed TL, such as the stress tolerance, mood states, muscle soreness, and perceived recovery. Future studies should investigate these responses to FT training in order to improve the quality of the training monitoring.

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