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Description of training loads using whole body exercise during high-intensity-interval-training

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Abstract

Aim: Recently, the association between HIIT and exercises using whole body mass or HIIT body work has gained popularity in fitness clubs and amongst professional athletes, however, knowledge about the acute adaptations of training load parameters of this modality is still inconclusive. **Materials and methods:** 20 male individuals (24 ± 3 years) performed a HIIT body work protocol consisting of a single bout of exercise with 1:1 stimuli. The exercises used were: 30” in duration with “all out” intensity. The exercises included jumping jack, mountain climb, burpee and squat jump. There were time durations of 30” observed for passive recovery, totaling 20 minutes of exercise. During exercise, total movement capacity, blood lactate measurement, rate of perceived exertion and recovery, training load and intensity were monitored. **Results:** All subjects performed the single bout of exercise without presenting any injury. The single bout examined had a total amount of 382 ± 89 movements. However, differences ($p<0.01$) in the total amount of movement for each exercise were noted indicating difficulty of maintenance of exercise over time. Increases in lactate concentration (Before: 0.98 ± 0.16, after: 14.10 ± 1.66; mMol/L) were found post exercise session. Statistical differences ($p<0.01$) were found after the fifth set and remained higher compared to the first set for movement capacity, demonstrating high load in one single session. No differences ($p>0.05$) were found in RPE during sets, however, from the second set the rate of perceived recuperation values were statistically ($p<0.01$) lower than the first set. **Conclusion:** the exercise protocol used in this study was of a high intensity and produced large values for stress during performance, with increase recorded in the internal load indicators such as heart rate, lactate concentration, effort and perception of recovery. Additionally, there was also an impairment of the external load indicators associated with the number of movements performed during the series.

Key words: exercise, whole body exercise, training monitoring, high intensity interval training, training load

Introduction

Participation in regular physical activity is associated with many health benefits, these include: body fat reduction (SHIRAEV & BARCLAY, 2012), cardiovascular improvement, lean body mass enhancement (CORATELLA & SCHENA, 2016), the development of increased self-esteem (FORTIER et al., 2016) and a more efficient functional capacity (DISTEFANO et al., 2013). In relation to this, numerous strategies have been developed to encourage greater population participation in physical activity practice (SPERANDEI et al., 2016). High intensity interval-training (HIIT) has been observed as an effective method to reduce insulin resistance (SHABAN et al., 2014), provide improvements in sports performance (NAIMO et al., 2015) while promoting positive changes in body composition (FALCONE et al., 2015). Although HIIT has been shown to be an effective method to promote physical activity gains, the extent of the benefit is dependent on the quality and quantity of training stimuli (PINHO et al., 2016).

Recently, the association between HIIT and exercises using whole body mass or HIIT body work has gained popularity in fitness clubs and amongst professional athletes. However, knowledge about the adaptations resulting from this exercise modality is still inconclusive (McRae et al. 2012, GIST et al. 2015). The work of GRAY et al. (2016) demonstrated that HIIT body work can result in physiological development that is convenient in relation to time management with cost effective low operational management compared to traditional training methods. Although the modality is considered simple and easy to use, training load manipulation (Machado et al. 2017) should be well monitored to guarantee feasible control, efficacy and security.

The monitoring of training load is considered to be of the main factors in the design of physical training programs (Bellenger et al., 2016). According to Impellizzeri et al. (2005), the training load could be used/implemented in external (ETL) and internal training conditions (ITL). The exact definition of ETL is still unclear, and needs clarification, but parameters like total volume, work done and time under pressure can be quantified. This can be achieved by using the number of repetitions per overload used, distance covered, number of sprints and amplitudes reached. These are all indicators frequently used to monitor training loads (ROCHEL et al., 2011). The ITL can be considered as an individual specific physiological adaptation that has occurred as the result of a workload (physical training stress) provided by external ITL. This highlights that there are individual physiological and psychological characteristics that respond to external exercise stimulus (Impellizzeri et al., 2005). ITL parameters like heart rate variability, oxygen consumption, lactate concentration and subjective perception of effort, are often used to measure responses to exercise (Foster, 1998; Bellenger et al., 2016).

Additionally, the monitoring of training session methods have also been considered as important strategies for adjusting training loads (Wallace et al., 2014; Foster et al., 2017). The model developed by Foster et al. (2001), quantifying the training load using the subjective perception of effort and the volume of exercise in minutes, has been the most prominent. Nevertheless, there are no scientific experimental studies characterizing HIIT body work using ETL and ITL parameters. Therefore, the objective of this study was to describe ETL and ITL through sets of a single session on HIIT body work.

Materials and Methods

Sample

After the approval of USJT research ethics committee (nº 1.738.246/2016), a consent document was signed by twenty healthy adult men (24 ± 3 years), who were physically independent, and volunteered to participate in this study. The following parameters were used as exclusion criteria: positive clinical diagnosis of diabetes mellitus, smoking, musculoskeletal complications and/or cardiovascular alterations confirmed by medical evaluation.

Exercise protocols

A single acute bout high-intensity interval training based on full body exercise was performed according to MACHADO et al. 2017. Briefly, the training session involved 5 min warm-up followed by 20 sets of 30 seconds of all-out exercise and 30 seconds of passive recovery between sets. Jumping jack, mountain climb, burpee and squat jump were used in the protocol.

Evaluated parameters

Anthropometric

Height was measured by a Cardiomed (WCS model) stadiometer, with an accuracy of 115/220 cm. The measurement was performed with the cursor at an angle of 90°, with the patient in a standing position with feet together in contact with the Stadiometer. The subjects were instructed to stay in inspiratory apnea, with the head parallel to the ground. Total body mass was measured by a calibrated Filizola electronic scale (Personal Line Model 150) with a 100g scale and a maximum capacity of 150 kg. Body mass index (BMI, kg/m^2) was calculated using the equation BMI = $weight/height^2$.

Total movement capacity

The total exercise movement amount realized on each set was used as external training load, as suggested by Machado et al. (2017).

Blood lactate measurement

Capillary blood samples were taken from a sterile fingertip using a sterile lancet. The first drop of blood was discarded, and freeflow blood was collected in glass capillary tubes. All blood samples (25 ml) for lactate analysis were evaluated using a Accutrend® (Roche – Basel, Switzerland).

Rate of perceived exertion and recovery

Subjects reported their rating of perceived exertion (RPE), immediately at the end and before each exercise set according to Borg (Borg, 1982). Recovery was measured with a scale adapted by Laurent et al. (2011) with values on the scale ranging from 0 to 10. The closer to the value 10, the greater the recovery perception of the practitioner.

Training load and intensity

Heart rate was recorded continuously throughout the training session using Polar HR monitors (Polar Oy, Finland). The HR data were recorded every 5 seconds. In an attempt to reduce heart rate recording error during training, all subjects were asked to check their HR monitors before each session and after each set (~10 min). Following each training session, HR information was then downloaded to a mainframe computer using Polar Advantage Software.

The ITL was obtained from the RPE value multiplied by the training session duration. Additionally, the total distance (km) covered at the 40 min time point, and the total exercise movement amount recorded on HIIT session were used as external load indicators. Further to this, the Edwards17 HR-based method of determining workload based of HR response involved integrating the total volume of the training session with the total intensity of the exercise session. An exercise score for each training bout was calculated by multiplying the accumulated duration in each HR zone by a multiplier allocated to each zone (50% to 60% HRmax = 1, 60% to 70% HRmax = 2, 70% to 80% HRmax = 3, 80% to 90% HRmax = 4, and 90% to 100% HRmax = 5) and then totaling the results. The maximal heart rate was determined according to the equation by TANAKA et al. (2001).

The intensity of the single session was measured by the rate of RPE which was assessed for each subject during the period of study. The calculation consists of multiplication of the training session duration in minutes by the exercise intensity, indicated by the RPE scale [5,6]. Briefly, subjects were told to choose a number from 0 to 10 (maximum value corresponds to the highest physical exertion experienced by the individual, and the minimum value is the rest condition). The subjects were asked to respond to the question: “How was your training today?” at 20 to 30 minutes post exercise. Additionally, the internal training load was calculated by multiplying the total movements performed in one single session and RPE.

Statistical analysis

The D’Agostino–Pearson test was applied to Gaussian distribution analysis. The paired Student’s t-test and ANOVA repeated measurements followed by Kruskal–Wallis posthoc test were performed to compare differences during the exercise session. An alpha of 0.05 was used to determine statistical significance. All data values were expressed as a mean ± standard deviation. All analyses were performed using SPSS software (v 15.0; IBM, Armonk, NY, USA).

Results

The participants presented no injuries as a result of the workout during and after the exercise session. The biometric parameters assessed are described in Table 1.

INSERT TABLE 1

figure 1 shows the total number of movements in each exercise. No differences were found between each set of exercise, however, differences ($p<0.01$) in the total amount (382 ± 89) of movement were found in combined exercises indicating difficulty in maintenance of exercise with high metabolic rates.

INSERT FIGURE 1

As shown in figure 2, significant differences ($p<0.001$) were found between lactate concentration (Before: 0.98 ± 0.16, After: 14.10 ± 1.66; mMol/L).

INSERT FIGURE 2

As described in figure 3 the values for heart rate (Panel A) and % based on maximal heart rate (Panel B) at 5º to 10º and 16º to 20º sets were statistically higher than the 1st set. As described in figure 1, these data suggest that combined exercise indicates impairment of maintenance and greater efforts required for these exercises due to high metabolic demand. Furthermore, it is possible to state that the first set of the total exercise session, comprising of pattern exercises, does not promote significant changes when compared to combined exercises.

INSERT FIGURE 3

The internal load of the single exercise session is described in figure 4. Statistical differences ($p<0.01$) were found after the fifth set and remained higher compared to the first set, demonstrating high load in one single session. Additionally, all subjects related high intensity exercise by RPE (9.5 ± 0.85) and the internal load characterized by movements performed on single session and RPE was 3824 ± 893.

INSERT FIGURE 4

The rates of RPE and recovery are shown in figure 5. No differences ($p>0.05$) were found in RPE during sets, however, from the second set the rate of perceived recuperation values were statistically ($p<0.01$) lower than on the first set.

INSERT FIGURE 5

Discussion

The control of loads during the performance of HIIT is challenging to coaches and practitioners, when body weight is used. This makes it extremely difficult to objectively quantify the external loads used.

Many authors (McRae et al., 2012; Machado et al., 2017) have suggested that HIIT exercise programs should be conducted in an *all-out* format. This means that the subjects should be performing the exercises at maximal intensity, with the highest number of movements and the most repetitions in the exercise period. However, research relating to the immediate physiological responses resulting from this type of activity is scarce. However, the main findings in the present study correspond to the quantification of variables consolidated in the literature as training load indicators. Our results revealed that the number of movements performed in each exercise series has diminished, as compared to the first series in both the Burpee and in the squat jump exercise.

Blood lactate concentration increased significantly at the end of the exercise period, by approximately 1.400% when compared to the beginning of the session. This indicates high glycolytic contribution, metabolic acidosis, and potential fatigue. These metabolic conditions did not impair the performance of the jumping jack and mountain climb series. This indicates that exercises requiring greater muscular strength levels (Burpee and squat jump) are more prone to the effects of acidosis and muscular fatigue.

Indeed, Fink et al., (2016) showed that during high metabolic stress conditions the number of repetitions made in a subsequent series of strength exercises diminishes drastically. Our results contribute to the development of bodywork HIIT programs when the objective is to maintain the number of exercise repetitions during the training session. Also, in addition to the reduction observed in the number of repetitions of the exercises with higher physiological demand, both the burpee and squat jump provide a greater increase in cardiovascular response compared to the first series and mean values recorded, which was not observed in the other exercises.

Although the subjective perception of effort has remained near to the maximum value (10) in almost all the series, characterizing the effort as *all out*, the internal load mean values also presented a higher trend in complex exercises. This confirms that such exercises (the ones mobilizing greater quantity of muscular mass and technical difficulty) call for more strength and greater physiological responses when compared to the exercises demanding less strength. A possible explanation for this fact, in addition to the metabolic demand previously documented in the literature could be that the higher intensity exercises result in more occlusion in the capillary muscles used, caused by muscular tension. This will contribute to the increase in the peripheral vascular resistance and, consequently, increase in heart rate (Polito and Farinatti, 2006).

Another tool commonly reported in the literature as a viable strategy to control training load is the use of scales of subjective perception of effort. This tool has been used for years as a reliable way to monitor the intensity of the workout (Eston & Connolly, 1996). McLaren et al., 2017 point out that these scales are ideal for controlling the internal load in cyclical high-intensity activities because they isolate the specific demands of different forms of training.

In the present study RPE was maximum in almost all the 20 series. Also, recovery, monitored by PSR, fell appreciably following the beginning of the exercise series. Several factors may contribute to these observations: 1) the movements' complexity; 2) the speed asked for in the stimuli (all out); 3) the short interval for recovery (30 seconds).

Also, the exercises used in this study involved integrated actions such as jumping and pushing, which demand a greater contribution from muscular volume during their execution. This demand is also related to the complexity of the movements involved. Great complexity tasks are more liable to generate central and peripheral fatigue, which directly affects the quality of recovery (O'Leary et al., 2017), as observed in this study following the burpee exercise. Moreover, the execution of high-speed movements could also be associated with fatigue due to the increase in intensity during the exercise period (Halson, 2014).

Finally, it is well documented in the literature (Bottaro et al., 2010; Nogueira et al., 2012; Dalamitros et al., 2016) that short intervals during the recovery phase also contribute to greater residual fatigue between the stimuli. This is associated both with PCr and ATP concentrations (Frazão et al., 2016), which stimulate the participation of glycolytic metabolism during this type of activity thereby increasing blood lactate levels.

In conclusion, the exercise protocol used in this study was of a high intensity and produced large values for stress during performance. There was also an increase recorded in the internal load indicators such as heart rate, lactate concentration, effort and perception of recovery. There was also an impairment of the external load indicators associated with the number of movements performed during the series. This was mainly found in the exercises that required greater complexity using large muscle groups.

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Figure legends

Figure 1. Values are presented as a mean ± standard deviation. *p<0.01 vs the 1rst set of each exercise.

Figure 2. Values are presented as a mean ± standard deviation. *p<0.001 vs. before.

Figure 3. Values are presented as a mean ± standard deviation. Panel A: absolute heart rate. Panel B: relative heart rate (% of max). *p<0.001 vs. 1rst set.

Figure 4. Values are presented as a mean ± standard deviation rate of internal load immediately at the end and before each exercise set. *p<0.001 vs. 1rst set.

Figure 5. Values are presented as a mean ± standard deviation rate of perceived exertion (RPE) and recovery (RPR) immediately at the end and before of each. *p<0.001 vs. 1rst set

Tables

Table 1. Sample characteristics.

Parameters	Mean ± SD	95% of IC
Body mass (kg)	74.0 ± 17.5	61.5 – 86.5
Height (cm)	1.7 ± 0.1	1.6 – 1.7
BMI (kg/cm^2)	26.3 ± 4.6	23.0 – 29.6

Values are presented as mean ± standard deviation.

Figures

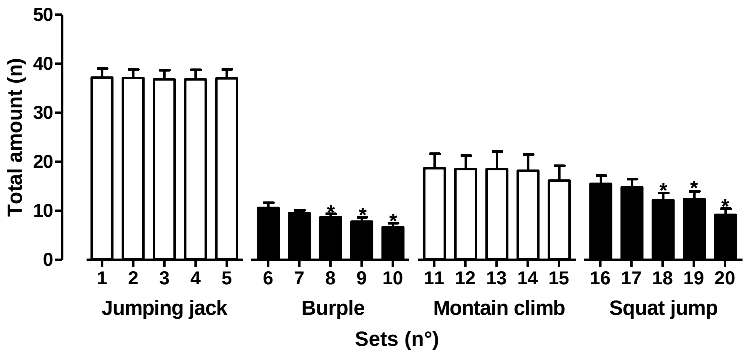

Figure 1.

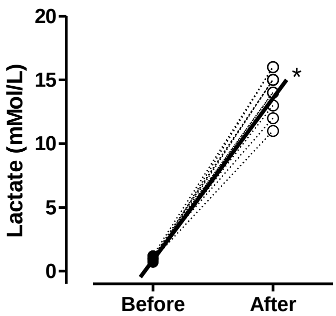

Figure 2.

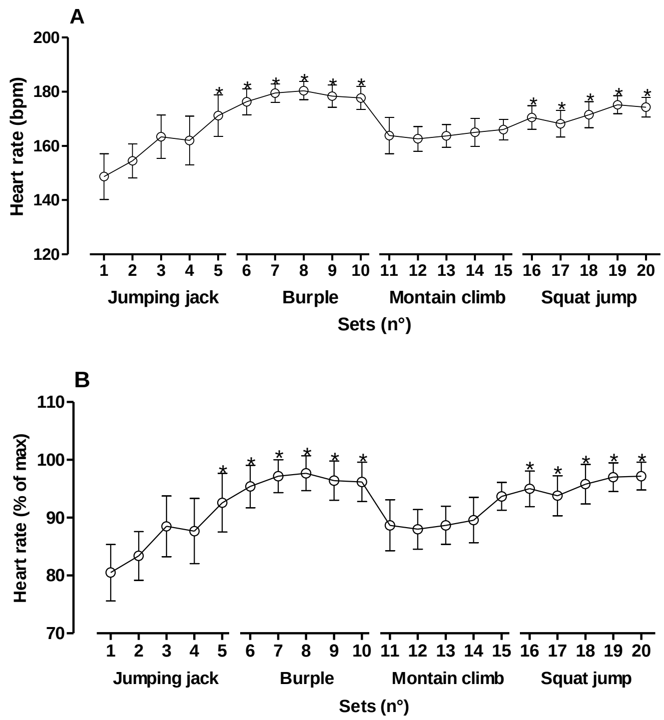

Figure 3.

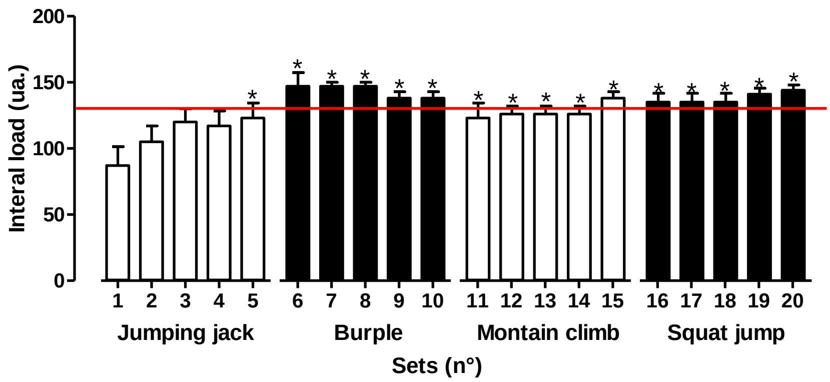

Figure 4.

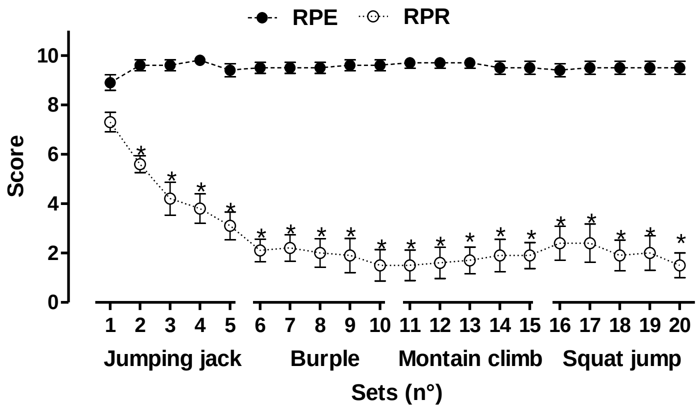
RPE
RPR
Score
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Jumping jack
Burple
Montain climb
Squat jump
Sets (n°)

Figure 5.