Original article (short paper)

Perception of effort monitors internal load during compounded circuit training

Alessandra de Azevedo
Universidade Positivo, Curitiba, PR, Brasil

Lorena Fernanda de Matos
Universidade Federal do Paraná, Curitiba, PR, Brasil

Fábio Yuzo Nakamura
Universidade Estadual de Londrina, Londrina, PR, Brasil

Gleber Pereira
Universidade Federal do Paraná, Curitiba, PR, Brasil

Abstract—The aim of this study was to determine if rating of perceived exertion (RPE) could be used to monitor the internal load during compounded circuit training (CCT) sessions in women. Thirteen young adults women performed three sessions of CCT varying the intensity according to participants' maximum heart rate (50, 70 and 90%HR_{max}). Throughout the main part of CCT (35min), HR and RPE were measured. Both variables were significantly different among the exercise intensities. However, HR and RPE were not correlated. Probably because HR at the end of exercise was similar to the beginning at 90% and 70% of HR_{max} intensities, and lower than the beginning instant at 50% of HR_{max} intensity, whereas RPE increased from the beginning instant to the end of exercise for all intensities. Therefore, RPE is suitable to monitor the internal load during CCT sessions in women due to its possibility to detect the (in)tolerance to exercise, despite of the lack of correlation with HR.

Keywords: rating of perceived exertion, circuit weight training, heart rate.

Introduction

The circuit-weight training method, characterized by alternating exercises between upper- and lower-body segments performed at stations, has been widely used in fitness-related practice settings (Aniceto *et al.*, 2015). The physiological strain can be increased alternating strength and aerobic exercises, which maximizes the time-efficiency while addressing several aspects of physical fitness (Skidmore, Jones, Blegen, & Matthews, 2012). Such combination has been defined as compounded circuit training (CCT) (Monteiro *et al.*, 2008).

The CCT has been shown to be an adequate training strategy to produce cardiovascular improvements and greater energy expenditure for both men and women (Monteiro *et al.*, 2008). However, monitoring exercise intensity during the CCT has been neglected, in spite of its key role on modulating training adaptations, by controlling the workload during the sessions. Heart rate (HR) has been frequently used to quantify the physiological exercise intensity in high-intensity interval training (Ciolac *et al.*, 2014; Green *et al.*, 2006) and circuit-weight training (Skidmore *et al.*, 2012). On the other hand, perception of effort has been suggested to easily monitor exercise intensity in circuit-weight training (Skidmore *et al.*, 2012) and high-intensity interval training (Ciolac *et al.*, 2014; Green *et al.*, 2006). Thus, it would be useful to determine if perception of effort can also be used to monitor the internal load (physiological/perceptual strain) during CCT sessions.

The perception of effort, defined as the conscious sensation of how hard, heavy, and strenuous a physical task is (Goldstein, 2009; Marcora, 2010) and measured through the rating of perceived exertion (RPE) scale (Borg, 2000), has presented good correlation with physiological variables (e.g., HR, oxygen consumption and blood lactate concentration) in incremental exercise (Borg, Gunnar; Ljunggren, Gunilla; Ceci, 1985; Psycharakis, 2011; Wolff, René, & Faculté, 2003). However, such a relationship can be inflated by the corollary increase in both physiological response and perception of effort during incremental protocols. Nevertheless, it is hypothesized that RPE and HR would be significantly correlated during CCT sessions performed at different intensities. Thus, RPE could be a useful tool to monitor the internal load during CCT sessions, since it has been applied at a number of gyms specifically designed for women. Therefore, the aim of this study was to determine if RPE could be used to monitor the internal load during CCT sessions in women.

Materials and methods

Participants

Thirteen physically active young healthy women (24.8 ± 3.6 years, 64.0 ± 7.0 kg, 170 ± 10 cm, 23.0 ± 3.0 kg/m²) agreed to participate in this study. The Ethics Committee of the University approved the experimental procedures of this study (CAEE 45901015.0.0000.0093). The participants received information about the study and signed a consent form before starting the procedures.

Experimental procedures

The participants performed three sessions of CCT at different intensities, 50%, 70% and 90% of their maximum heart rate (HR_{max} = 220 – age), on different days. These intensities were based on a previous familiarization session with the experimental procedures, which also was used as a pilot study. All sessions were separated by six days, always performed at the same period and by the same researcher. During the whole experimental period, it was requested that the participants maintain their physical and dietary habits, and to avoid strenuous exercise 48h before each session. The participants were divided into four groups. Each group had its training intensity order randomly assigned. The training sessions consisted of 5 min warming up, 35 min as the main part performing the CCT, and 5 min of relaxation. During the main part, HR and RPE were measured every 5 min. A portable device (Electro FT1, Polar, Kempele, Finland) was used to monitor the HR. The 6-20 Borg scale was used to monitor the perception of effort (Borg, 2000). All the participants were familiar with the CCT and RPE scale.

However, to avoid misinterpretation to report perception of effort, before every session, the participants received the following instructions to use the RPE scale: "During the exercise, we want to evaluate your perception of effort. It depends on how difficult, heavy and hard is for you to exercise your legs or arms, how difficult it is to breathe, and general feeling of strain for the exercise. It does not depend on pain and burning sensation in your muscles of legs or arms. Look at this scale, where 6 means "no effort, at rest" and 20 means "maximal exertion". A score of nine corresponds to a "very light" exercise for a person which is like walking slowly at your own pace for a few minutes. A score of thirteen is an exercise "somewhat hard" but it still feels good to keep going. A score of seventeen or "very hard" is a very vigorous exercise, in which person can still perform it, but he/she really has to struggle and feeling of much difficulty and tired. A score of nineteen is an "exhaustive" exercise, being the most intense workout ever experienced. Try to evaluate your exertion feelings as honestly as possible, without thinking about the workload (e.g., heart rate, speed, power, intensity level of the exercise machine). It is important to rate your own feelings of effort, not how it compares to others. Any questions?"

Compounded circuit training

The training sessions consisted of alternating weight and aerobic exercises, controlled by time, and varying active and passive resting periods between exercise sets (Table 1). The first exercise intensity of CCT was based on a familiarization session.

Table 1. Exercises performed during the compounding circuit training sessions at different intensities.

50% HRmax Protocol **6 exercises** **Total Time: 35 minutes**	**70% HRmax Protocol** **6 exercises** **Total Time: 35 minutes**	**90% HRmax Protocol** **6 exercises** **Total Time: 35 minutes**
1. Bent Over Rows with bag (3kg) + Unilateral Skipping (2x20s + 2 min)	1. Agility Ladder + TRX Bent Over Rows + Jackknife Abdominal (3x45s + 20s + 20s)	1. Olympic Lifting with weight bar (8kg) (2 x 1min30s + 30s passive rest)
2. Push Ups Inclined + Squat + Walk (3x20s + 30s + 1min30s)	2. Agility Ladder + Zig-Zag run (2x45s + 45s)	2. Olympic Lifting with weight bar (8kg) + Stationary Run (3x40s + 40s)
3. Unilateral Skipping + Quick walk (4x30s + 15s)	3. TRX Push Ups + Lunge Step + Agility Ladder (3x30s + 30s + 1 lap in agility ladder)	3. Arm swing combined with Stationary Sprint Run + walk (4x20s + 10s)
4. Lunge + Bent Over Rows unilateral with halter (1kg) (3x20s + 20s + 1min passive rest)	4. Skipping + Agility Ladder (2x50s + 50s)	4. Skipping followed by stationary sprint + Bicycle Crunch Abdominal. (3x30s + 30s)
5. Stationary Run + Sit Up Abdominal (4x40s + 20s)	5. Push Ups In Agility Ladder + TRX Single Leg Squat (2x1 lap in agility ladder + 40s)	5. Deadlift combined with Skipping + Bicycle Crunch Abdominal. (3x 30s + 10s)
6. Hip Lifting with bag (3kg) + Oblique Abdominal (3x20s + 20s)	6. Stationary Run + Walk (4x30s + 15s)	6. Plank Abdominal + Reverse Plank (3x40s + 20s; 1min passive rest).

Statistical Analysis

The estimated power for comparisons of heart rate and perceived exertion was 0.94 for the number of participants in the present study. Data normality and homogeneity of variance were verified through Shapiro-Wilk and Levene tests, respectively. Then, two-way repeated measures ANOVA was run to determine differences between intensity (50, 70 and 90% HR_{max}) and time (5, 10, 15, 20, 25, 30, 35 min) for the dependent variables. Bonferroni post hoc test was used for multiple comparison purpose. The relationship between heart rate and perceived exertion at different intensities was checked using Pearson's correlation coefficient. The level of significance was $p < 0.05$.

Results

There was interaction between intensity and time for both HR (p=0.002) and RPE (p=0.003). Moreover, the HR was significantly different among the intensities at iso-time (same instant) (Figure 1, upper panel). The RPE was also significantly different among the intensities at iso-time (Figure 1, lower panel). However, HR and RPE presented different patterns over the time (Figure 1).

There was no correlation between heart rate and perceived exertion at different exercise intensities [50% (r= -0.11; p=0.31), 70% (r= -0.01; p=0.9) and 90% HR_{max} (r=0.15; p=0.14)].

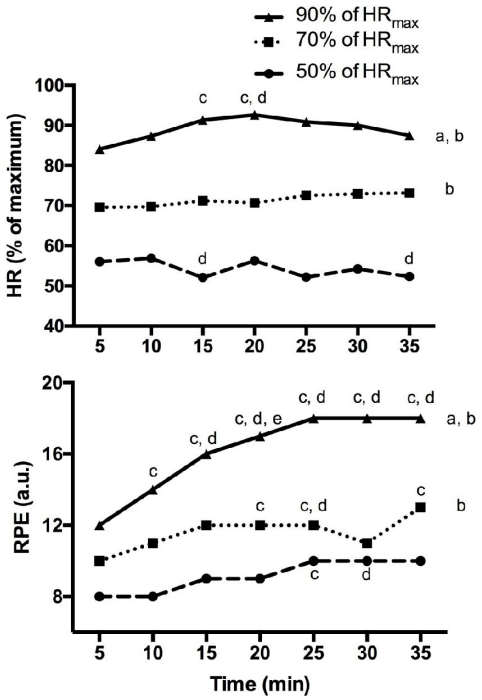

Figure 1. Mean and standard deviation of heart rate (HR) (upper panel) and rating of perceived exertion (RPE) (lower panel) at different instants during different compounding circuit training sessions based on maximum HR. For both HR and RPE variables: 90% of HR_{max} exercise intensity was significantly different from 70% and 50% of HR_{max} exercise intensities at iso-time (same instant) for the whole session; 70% of HR_{max} exercise intensity was significantly different from 50% of HR_{max} exercise intensity at isotime for the whole session. [a]Significantly different from 5 min at the same intensity; [b]Significantly different from 10 min at the same intensity. [c]Significantly different from 15 min at the same intensity.

Discussion

The aim of this study was to determine if perception of effort could be used to monitor the training load during CCT sessions performed at different intensities in women. Both variables - HR and RPE - were different among the CCT intensities, in which they were greater in sessions with higher exercise intensities. However, these variables presented different temporal pattern throughout the sessions, being not significantly correlated in any of the exercise sessions.

HR and RPE were greater during the sessions performed with higher exercise intensity. Such response is based on the manipulation of intensity through the active resting intervals between sets and multi-joint exercises performed at 70% and 90% of HR_{max}, requiring greater physiological demand (Ciolac *et al.*, 2014; Polito, 2015). However, HR and RPE were not significantly correlated at different exercise intensities during the CCT sessions. Previous studies have reported relationship between these variables during incremental workload exercise and during high-intensity interval training (Borg, *et al.* 1985; Psycharakis, 2011; Wolff *et al.*, 2003). On the other hand, previous study has shown different temporal pattern of HR and RPE changes during CCT (Skidmore *et al.*, 2012). Similarly, in the present study, the overall RPE increase occurred from the middle to the end of exercise session for all intensities. In contrast, HR at the end of exercise was similar to the beginning instant at 90% and 70% of HR_{max}, or at the end of exercise HR was lower than the beginning instant at 50% of HR_{max}.

It has been shown that HR is a relatively poor indicator of exercise intensity during intermittent training (Foster, *et al.*, 2001). The RPE has increased during the exercise even when physiological variables have been stabilized (Pires *et al.*, 2011). Moreover, it has been reported that previous mental fatigue has increased RPE, whereas neither HR nor oxygen consumption have changed (Marcora, Staiano, & Manning, 2009). The lack of correlation between HR and RPE, in these studies and in the present, can be explained based on the Psychobiological model, which postulates that perception of effort is the conscious awareness of the central motor command sent to the active muscles, independent of peripheral afferent feedback signals (Marcora, 2009; Smirmaul, Dantas, Nakamura, & Pereira, 2013). Therefore, as RPE is generated independently from other physiological responses (e.g., HR and oxygen consumption), it can be used not only to monitor exercise intensity, but also to detect the (in) tolerance to exercise (Rodríguez-Marroyo, Villa, García-López, & Foster, 2012). In fact, RPE has been shown to be more sensitive to the accumulated fatigue caused by prolonged multiple-day cycling race than HR (Rodríguez-Marroyo *et al.*, 2012).

Based on these arguments, RPE can be useful to monitor the training load during CCT sessions for women, although there was no correlation between HR and RPE. From a practical point of view, practitioners are suggested to use RPE scale during CCT sessions, since exercise (in)tolerance (i.e., task disengagement) is much more related to RPE than to other physiological variables, such as HR. Thus, to maintain a target level of RPE during each CCT, the HR can be even reduced over the exercise session. Future studies are needed to address the training effects of CCT guided by RPE.

Conclusion

Although there was no correlation between HR and RPE, it can be suggested that RPE can be useful to monitor the training load during CCT sessions for women, since it presents the possibility to detect the (in)tolerance to exercise. Empirically, healthy women can feel difficulty to maintain the exercise intensity during CCT, despite of HR stabilization throughout the session.

References

Aniceto, R.R., Ritti-Dias, R.M., dos Prazeres, T.M.P., Farah, B.Q., de Lima, F.F.M., & do Prado, W.L. (2015). Rating of perceived exertion during circuit weight training. *Journal of Strength and Conditioning Research*, (MAY), 1. http://doi.org/10.1519/JSC.0000000000000998

Borg, G. a. (2000). *Escalas de Borg para a dor eo esforço*.

Borg, G.; Ljunggren, G.; Ceci, R. (1985). The increase of perceived exertion, aches and pain in the legs, heart rate and blood lactate during exercise on a bicycle ergometere. *European Journal of Applied Physiology and Occupational Physiology*, *54*(4), 343–349.

Ciolac, E., Mantuani, S., Neiva, C., Veradi, C., Pêssoa-Filho, D., & Pimenta, L. (2014). Rating of perceived exertion as a tool for prescribing and self regulating interval training: a pilot study. *Biology of Sport*, *32*(2), 103–108. http://doi.org/10.5604/20831862.1134312

Foster, C, Florhaug, J.A., Franklin, J., Gottschall, L., Hrovatin, L.A., Parker, S., Doleshal, P., and Dodge, C. (2001). A New approach to monitoring exercise training. *J Strength Cond Res*, *15*, 109–115.

Goldstein, E. B. (2009). *Encyclopedia of perception*. Los Angeles.

Green, J.M., Mclester, J.R., Crews, T.R., Wickwire, P.J., Pritchett, R.C., & Lomax, R.G. (2006). RPE Association with Lactate and Heart Rate during High-Intensity Interval Cycling. *Medicine & Science in Sports & Exercise*, *38*(1), 167–172. http://doi.org/10.1249/01.mss.0000180359.98241.a2

Marcora, S. (2010). Afferent Feedback From Fatigued Locomotor Muscles Is Not an Important Determinant of Endurance Exercise Performance. *Journal of Applied Physiology*, *108*(2), 454–456. http://doi.org/10.1152/japplphysiol.00976.2009a

Marcora, S.M. (2009). Perception of effort during exercise is independent of afferent feedback from skeletal muscles, heart, and lungs. *Journal of Applied Phyiology*, *106*, 2060–2062. http://doi.org/10.1152/japplphysiol.90378.2008

Marcora, S.M., Staiano, W., & Manning, V. (2009). Mental fatigue impairs physical performance in humans. *Journal of Applied Physiology*, *106*(3), 857–864. http://doi.org/10.1152/japplphysiol.91324.2008

Monteiro, a G., Alveno, D. a, Prado, M., Monteiro, G. a, Ugrinowitsch, C., Aoki, M. S., & Piçarro, I. C. (2008). Acute physiological responses to different circuit training protocols. *The Journal of Sports Medicine and Physical Fitness*, *48*(4), 438–42. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18997645

Pires, F.O., Lima-Silva, A.E., Bertuzzi, R., Casarini, D.H., Kiss, M.A., Lambert, M.I., & Noakes, T.D. (2011). The influence of peripheral afferent signals on the rating of perceived exertion and time to exhaustion during exercise at different intensities, *48*, 1284–1290.

Polito, M. (2015). Arterial E Duplo- -Produto Ao Exercício Contra-Resistência : Uma Revisão Da Literatura, (October).

Rodríguez-Marroyo, J.A., Villa, G., García-López, J., & Foster, C. (2012). Comparison of Heart Rate and Session Rating of Perceived Exertion Methods of Defining Exercise Load in Cyclists. *Journal of Strength and Conditioning Research*, *26*(8), 2249–2257. http://doi.org/10.1519/JSC.0b013e31823a4233

Skidmore, B.L., Jones, M.T., Blegen, M., & Matthews, T.D. (2012). Acute effects of three different circuit weight training protocols on blood lactate, heart rate, and rating of perceived exertion in recreationally active women. *Journal of Sports Science and Medicine*, *11*(4), 660–668.

Smirmaul, B.P.C., Dantas, J.L., Nakamura, F.Y., & Pereira, G. (2013). The psychobiological model : a new explanation to intensity regulation and (in)tolerance in endurance exercise. *Revista Brasileira de Educação Física E Esporte*, *27*(2), 333–340. http://doi.org/10.1590/S1807-55092013005000008

Psycharakis S.G.(2011). A longitudinal analysis on the validity and reliability of ratings of perceived exertion for elite swimmers. *Strength And Conditioning*, (6), 420–426.

Wolff, M., René, U., & Faculté, D. (2003). Reliability of Rating Scales of Perceived Exertion and Heart Rate During Progressive and Maximal Constant Load Exercises Till Exhaustion in Physical Education Students. *International Journal of Sports Medicine*, *24*(4), 285–290. http://doi.org/10.1055/s-2003-39502

Authors' note

Alessandra de Azevedo is affiliated with the Positivo University, Curitiba, PR, Brazil.

Lorena Fernanda de Matos is affiliated with the Physical Education Department, Federal University of Parana, Curitiba, PR, Brazil.

Fábio Yuzo Nakamura is affiliated with the Physical Education Department, State University of Londrina, Londrina, PR, Brazil.

Gleber Pereira is affiliated with the Positivo University, Curitiba, PR, Brazil and Physical Education Department, Federal University of Parana, Curitiba, PR, Brazil.

Corresponding author

Gleber Pereira
Universidade Federal do Paraná, Departamento de Educação Física, Rua Coração de Maria, 92 -BR 116 km 95, Jardim Botânico, Curitiba, Paraná, 80215-370, Brazil.
Email: gleber.pereira@gmail.com

Manuscript received on November 16, 2015
Manuscript accepted on November 25, 2015