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Original Article

The Rating of Perceived Exertion Predicts Performance Loss and Physiological Demand in Vertical Jump Session Until Voluntary Failure

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Abstract

The aims of this study were (a) to assess the ability of the rating of perceived exertion (RPE) to predict performance loss (i.e. percent of drop in height relative to maximal height) of vertical jump session until voluntary failure, and (b) to determine the ability of RPE to describe the physiological demand of this session via heart rate monitor. Ten healthy men performed vertical jumps (counter-movement jump) until voluntary failure. Before session start maximal jump height for every subject was determined. Heart rate and RPE, separately for legs (RPE legs) and for breath (RPE breath), were recorded every ten jumps throughout the sessions. Results have shoved that RPE legs and performance loss have about 99% of same variance (=0,9899; p<0,000), and RPE breath explains about 98% heart rate variance (=0,9789; p<0,000) in vertical jump session until voluntary failure.

1. Introduction

The raiting of perceived exertion (RPE) is a often used internal load measure in monitoring sport training. It is used in monitoring almost all types of exercises, and it's popularity is growing more and more. Reasons of that is because RPE is cost effective, time efficient, and also valid, reliable measure of internal load (Eston, 2012; Scott et al., 2016).

This internal load measure is sensitive on bigger and lower values of training intensity and volume. Also, RPE is sensitive on other acute training variables (Scott et al., 2016).

Using of RPE is done by established scales. There are few scales which are

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used, and research is done in many types of exercises by using all scales (Eston, 2012). The most common scales are Borg 6-20 category scale, OMNI – RES scale, and last one, which is of the most interence, and it is the most used, is Borg Category Racio 10 Scale (CR-10) (Borg, 1998; Borg, 1982).

There are two main types of RPE. One is session RPE, and the other is set RPE. First one is collected at the end of exercise, more precisely 10 min after is finished. In this way athletes rate whole session simply by CR-10 scale. This type of RPE is much more reshearched than the second – set RPE. The second is collected through the training session (between sets or somwhere across session). Because of that, this research paper whill be dealing with the second type of RPE (Lagally, & Robertson, 2006; McGuigan et al., 2004).

Very interesting way of using RPE is by collecting information of perceived effort of legs (RPE_{legs}) and breath (RPE_{breath}) separately. Which is proved to be valid and reliable in cycle ergometer exercise (Robertson et al., 2003).

RPE also has been used in intermittnet vertical jump exercise. Findings in this area suggest that RPE can been used to predict performance (nuber of jumps) and it is correlated to physiological measures (blood lactate and heart rate) of such exercise (Pereira et al., 2012).

Hardee et al. (2012) suggest that RPE is a measure of level of fatigue. This could mean that there is maybe relationship between set RPE and performance loss. In other words, for vertical jump session, it could be perceived perfomance loss and it could express it through RPE scale. This may be mesured by using RPE scale, but only for legs, whis is dominat part of body in vertical jumping.

Heart rate is related with RPE breath in cycle ergometer exercise, but this kind of relationship is not established in vertical jump session (Pereira et al., 2012).

Because there has been established reliablity and validity of RPE for legs, it is unknown if there is relationship between set RPE, for legs only, and performance loss in vertical jump session until voluntary failure. Also, relationship between heart rate (physiological demand) and set RPE, for breath only, is not established in this type of exercise session.

Aims are: a) to assess the ability of the RPE to predict performance loss (percent of drop in jump height relative to maximal jump height) of vertical jump session until voluntary failure, and b) to determine the ability of RPE to describe the physiological demand of this session via heart rate monitor.

2. Material and methods

Participants

Ten healthy men (mean±sd: age 23.8±2.8 years, height 183.0±5.6 cm, mass 79.6±8.7 kg) participated in this study. The participants were students of Faculty of sport and physical education, so they all had experience in vertical jumping activities, through learning basketball and volleyball. They were ased to refrain from unusual physical activity at least 48h before experiment. This study received approval from local research ethics comiteand the participants were informed of the procedures and risks of the tests before providing written consent.

Experimental design

Participants attended one familiarization and one experimental sessions. The familiarization session was designed to inform participants to the procedures of the experiment. In this familiarization session, experimenters explained to the participants the nature of the experiment. They familiarized with RPE CR-10 scale. As well, it was explained to them the correct way of counter-movement jump (CMJ) jumping, and the way they will continuously jump through the session. In the second (experimental) session, participant first performed maximal jump height determination, and then performed experiment, when they were fully rested. All jumping procedures were performed and measured on two force platforms. During the experimental sessions, RPE and heart rate were recorded until voluntary fatigue, which was when participants reported 10 for RPE_{legs}. Strong verbal encouragement was provided in all sessions.

Familiarization session

In the familiarization session it was explained the whole experiment to the participants. First matter in this session was introducing participants to the Borg's 15-point RPE scale (Borg, 1982). As well, it was explained to them the difference between RPE_{legs} and RPE_{breath}, as it was used elewere (Pereira et al., 2011). The specific instructional set used for the RPE scale has been reported elsewhere (Doherty et al., 2001). Briefly, participants to ‘‘anchor’’ the top and bottom perceptual ratings to previously experienced sensations of the easiest and most difficult exercise encountered (Doherty et al., 2001).

Next matter was explanation of CMJ jumps, and the wright way of completing every single jump. Participant needed to complete eccentric phase, then immediately concentric phase and then to take off phase, and after landing to get back to start point where their hip and knee were maximally extended. In the experimental session they would need to jump every single jump in just explained way. As well, it was explained the position of their legs and the way they will complete it on force platforms. Jumping and landing are always on force platforms. All CMJ jumping procedures (in maximal jump testing and in main part of experiment) were on force platforms. Via force platforms it was measured instantly the jump height. Jumps were performed on a force platform (Kistler 9286A, Wintherthur, Switzerland), which sampled ground reaction forces at a frequency of 1 kHz. Vertical ground reaction force data were smoothed using a zero-lag, fourth-order, low-pass digital Butterworth filter set at 13 Hz (Math Works, Inc., Natick, MA, USA). For measuring heart rate, participant weared heart rate watch, which usage was also explained by experimenter.

Experimental session

To participate in the main experimental session, participant needed to be fully rested (48h without any strenous activity). At the beginning of this session first was warp up, which was contained of 5 minutes of riding a cycle ergometer and 5 min of streching, with an accent on lower extremities.

After that they continued on maximal jump height (MJH) testing was consited of 15 CMJ jumps with 10 seconds of rest between them. Instruction in this part, and latter in the main session, was allways to jump as maximal as possible, for every single CMJ jump. Of the best five jump height, for every single participant, it was calculated the average value, and this was the measure of MJH. Relative to MJH, later (in the main session) was measured percent of drop in height. This was all measured on two force platforms.

After completing an MJH testing procedure, participants put a heart rate watch and rest. For starting a main session requirement was that heart rate was bellow 90 beats per minute, and subjective rate of effort on RPE CR-10 scale was minimum 1, for every single participant.

In the main session, participants were jumping CMJ jumps, allways as highest as possible, and every jump needed to be fully carried out. This meant that every single jump needed to have starting phase (extended hip and knees), than eccentric and concentric phase, take off and landing. Intervals between jumps were about 3 seconds. Before they started main session, signal on force plates were started and recorded at 500 Hz. At every 10^{th} jump (which were checkpoints) participants were stoped and asked about RPE_{legs}, RPE_{breath} and HR. After they told informations about internal load, they continued jumping (this pause was never longer than 10 seconds). This was happening until, on some checkpoint, participants rated their RPE_{legs} with number 10, which was voluntary failure. Average value of jump height of last three jumps before every checkpoint was a varible - perfomance loss, and this was calculated in percent (%) relative to MJH measure. As well, on every checkpoint this measure was calculated, so it could be related with RPE_{legs}.

Statistical analysis

For every variable on every checkpoint it was provided average values and standard deviation. To establish if there was relation between performance loss and RPE_{legs}; HR and RPE_{breath}, it was used regression analysis – polynomial model, which was model for the biggest relationship.

3. Results and Discussions

Table 1. *All variables - Mean (SD)*

Checkpoint (N)	Performance loss (%)	RPE (legs)	RPE (breath)	Heart rate (beats)	Jumps (n)
1	81,86 (3,96)	1,4 (1,07)	1,5 (0,85)	154,8 (18,94)	10
2	75,27 (4,09)	2,9 (0,99)	3,0 (1,25)	169,5 (15,80)	20
3	70,77 (3,69)	4,4 (1,17)	4,5 (1,51)	175,9 (15,33)	30
4	65,76 (6,49)	5,9 (1,66)	6,2 (1,81)	179,3 (13,80)	40
5	61,50 (4,09)	7,3 (1,83)	7,2 (1,69)	181,6 (13,58)	50
6	59,23 (7,94)	8,3 (1,77)	8,1 (1,60)	183,5 (12,67)	60
7	56,34 (9,02)	8,5 (1,40)	8,0 (1,53)	184,9 (14,45)	70
8	55,07 (3,12)	10,0 (0)	8,4 (1,52)	183,8 (15,83)	80

In Table 1, mean and standard deviation values, of every variable (in columns) and on every checkpoint (in rows), is provided. Variable performance loss shows mean (sd) values through checkpoints (on every 10th jump). These values were on every checkpoint, in order are: 1 - 81,86 (3,96), 2 -75,27 (4,09), 3 - 70,77 (3,69), 4 - 65,76 (6,49), 5 - 61,50 (4,09), 6 - 59,23 (7,94), 7 - 56,34 (9,02), 8 - 55,07 (3,12). Second variable was RPE_{legs}, and it's mean (sd) values, on every checkpoint, in order are: 1 - 1,4 (1,07), 2 - 2,9 (0,99), 3 - 4,4 (1,17), 4 - 5,9 (1,66), 5 - 7,3 (1,83), 6 - 8,3 (1,77), 7 - 8,0 (1,53), 10 (0). For variable RPE_{breath}, mean (sd) values, on every checkpoint, in order are: 1 - 1,5 (0,85), 2 - 3,0 (1,25), 3 - 4,5 (1,51), 4 - 6,2 (1,81), 5 - 7,2 (1,69), 6 - 8,1 (1,60), 7 - 8,0 (1,53), 8 - 8,4 (1,52). And , for last variable HR, mean (sd) values, on every checkpoint, in order is: 1 - 154,8 (18,94), 2 - 169,5 (15,80), 3 - 175,9 (15,33), 4 - 179,3 (13,80), 5 - 181,6 (13,58), 6 - 183,5 (12,67), 7 - 184,9 (14,45), 8 - 183,8 (15,83).

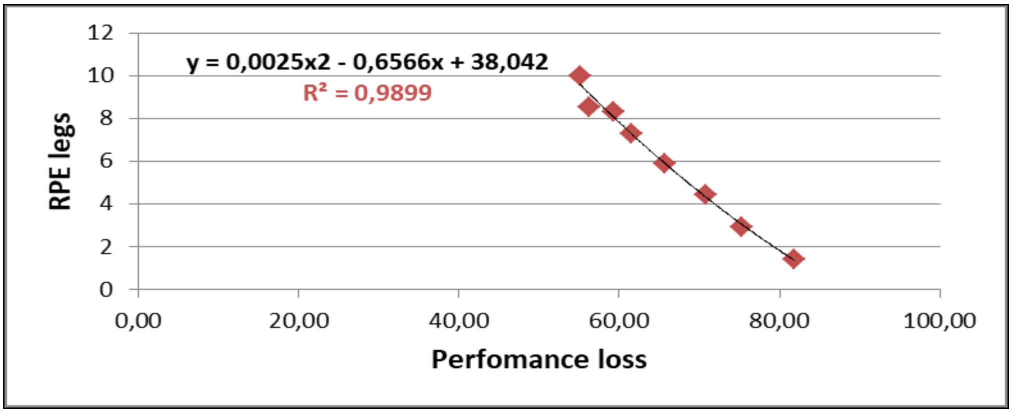

Figure 1. *Regression analysis between Perfomance loss and RPE legs*

In Figure 1, it is provided graphical view of relationship between RPE_{legs} (on y axis) and Performance loss (on x axis). As well, it is showed coefficient of determination between this two variables, an it's value is r^2=0.9899.

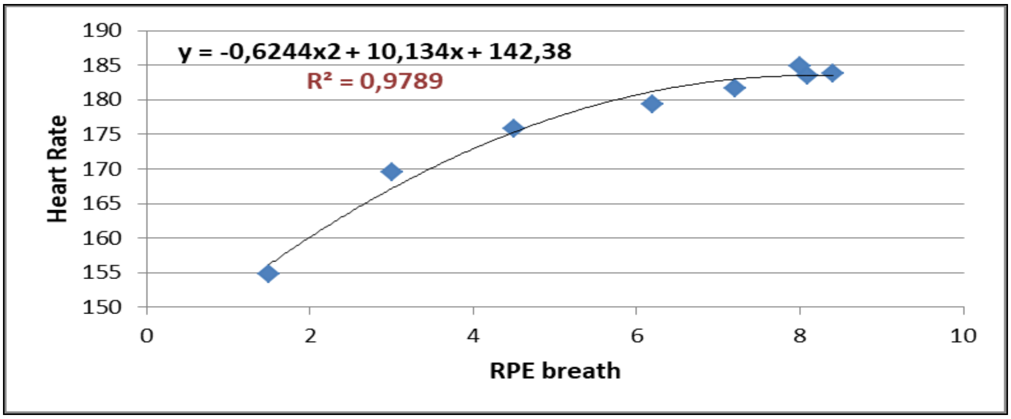

Figure 2. *Regression analysis between RPE breath and Heart Rate*

In Figure 2, it provided graphical view of relationship between HR (on y axis) and RPE_{breath} (on x axis). As well it is showed coefficient of determination between this two variables, an it's value is r^2=0.9789.

Discussions

The main findings is that RPE can predict performance loss of vertical jump session until voluntary failure, and b) RPE have ability to predict and describe physiological demand, which is also a measure of intensity, of vertical jump session until voluntary failure. These findings are supported by relationship between RPE_{legs} and performance loss (percent of drop in jump height relative to maximal jump height) - r^2=0,9899 , and a relationship between RPE_{breath} and HR (physiological demand) - r^2=0,9789. This means that RPE_{legs} and performance loss have an about 99% of the same variance, and HR and RPE_{breath} have an about 98% of the same variance.

This findings also means that RPE (at ovearal – RPE_{legs} and RPE_{brath}) represents the level of fatigue, in terms of declining of jump height (percent of drop in jump height relative to maximal jump height). When is fatigue raising, performance is declining, and RPE is raising. Main finding is that RPE is a measure of a fatigue, and because of that there is no need to measure performance loss (as measure of fatigue), in this kinf of study design. This view of RPE also is supported by measuring power output (Hardee et al., 2012; Naclerio et al., 2011). In this studies have been found that with RPE raising power output is decreasing in bench press and power clean. The difference is that in this study the measure of faigue was percent of drop in jump height relative to maximal jump height, and in other two studies the measure of fatigue was performance loss measured via decrease in power output.

The strong relationship between RPE_{breath} and HR (Figure 2) indicates that RPE can be used as a practical measure of vertical jump training demand. In fact, RPE has been shown to be a simple and valid method for quantifying whole training session intensity for vertical jump session until voluntary failure (Foster et al., 2001; Impellizzeri et al. 2004). In addition, RPE has been correlated with several physiological indicators of exercise intensity such as oxygen consumption, blood lactate concentration, and heart rate during a variety of exercise protocols (Chen et al., 2002; Eston et al., 2008; Nakamura et al., 2009). Taken together, these data suggest that RPE is a valid measure of the training demand for vertical jump training.

This is very useful for practioners and researchers because RPE, as a mesure, does not need much time and it's cost effective, and is a valid measure of fatigue and intensity in this type of training.

Limitation is design of the research. This means that stability of this relationships need to be tested again by using another acute trainning variables (different configurations of sets, training density, rest periods). Manipulation of this variables could test this strong realtionship, and maybe accept or decline this relation. So, in the future studies this could be investigated.

In conclusion, the results of the present study indicate that RPE can be used to predict the performance loss (fatigue) and physiological demand (HR) of vertical jump session until voluntary failure and is a practical measure of vertical jumping training demand.

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