Does Decision Making Affect Heart Rate in Trails? Heart Rate Response to Treadmill Walk with and without Adaptation

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Abstract

Walking in an irregular ground involves permanent adaptations that require: collecting information, its interpretation, and assembly of the appropriate strategies to perform the skill. With this study we aimed to understand what are the effects on heart rate (HR) when a person faces a situation where there is a constantly need to adapt. We've used a treadmill with several spots along the mat to constrain the person's gait. Each of the 20 subjects performed two situations: walking on the treadmill for 10 minutes-(1) without any restriction; and 2) without stepping the spots. A HR monitor (POLAR) was used to measure HR during both situations. Results showed that between the two situations (1 and 2) there was an increase in HR mean of 44 bpm. Findings reinforce that the constant need for decision-making requires a cost that reflects on the individual HR.

Keywords: Terrain Adaptations, Heart Rate, Gait, Decision Making

1. Introduction

The growth of tourism and ecotourism has led to an increase in the number of people who take trails on different types of terrain, as well as the diversification of practitioners' characteristics such as age, gender, physical condition, experience, etc. In this context, understanding the difficulty of a trail is crucial to customize the activity for the consumer, but also to provide information so that the activity can be safely performed. The Assessment of the difficulty of a trail/walk is usually based on factors such as the distance to be traveled, the altitude of the trail, the slope, the type of terrain, the weather conditions, whether the trail is marked or not, among others. There are several types of classifications that consider different factors, for example, Serrão (1987) refers the extent, the type of terrain, the unevenness, and the climatology. On the other hand, the Aragonese Mountaineering Federation (FAM, 2005) classifies trails in three difficulty levels: i) easy - reasonable in its extent and slope, well marked and without difficulties; ii) medium - requires an acceptable physical form as it can have areas where uneven terrain is crossed although with no major difficulties and iii) high - physical fitness is demanded due to the length of the trail and the significant unevenness, and experience in mountain activities is highly recommended. Also, Rodrigues &Torves (2007) classify the trails into three difficulty levels: i) difficult - slopes higher than 20%, with more than 10 obstacles every 500m with uphill climbs, very long stretches that requires some skill in walking and good physical condition, ii) medium - slopes of 12-20%, with 5-9 obstacles per 500m, with climbs to medium hills and short walks in native forest without requiring technical skills, iii) easy - slopes below 12% with a maximum of 4 obstacles per 500m and little physical effort is required.

The French Hiking Federation (FFRP, 2003) distinguishes 4 degrees of difficulty: i) very easy - duration less than 2 hours on a well-marked track; ii) easy - less than 3 hours on roads with some less easy passes; (iii) medium - duration of less than 4 hours, with some gradients and for experienced walkers; and (iv) difficult - longer than 4 hours on a long and / or difficult route.

Despite the different classifications of difficulty on trails, most seem to highlight the duration or length of the trail, the slope of the land and sometimes the obstacles, being notorious the relation between these factors and the physical condition of the individual. However, it is also visible a great subjectivity and in definition in terms of the type of language used and in its concepts.

Knowing the effects that terrain variations may have on the individual performance is essential to manage the activity according to individual characteristics and to prevent risk situations. One of the indicators that is nowadays more accessible to practitioners and allowing an easy control of effort effects is Heart Rate (HR). It is also frequently used as a physical fitness indicator and widely mentioned to classify hiking trails and walking paths. In this sense, it is possible to use HR as an indicator of the effort performed in these type of situations, since it is a non-intrusive and easy to apply method in ecological situations (Amorim, 2002). This indicator can also be used to control parameters such as physiological and cognitive activation (Fenz& Jones, 1972; Cratty, 1984, Robazza, Bortoli, & Nougier, 1998, Leite, Madrid & Bezerra, 2012).Several studies address the variation of HR in a walk according to factors such as terrain slope, transported load, speed, etc., however, the adaptation effect that walking on an irregular terrain causes is not yet well known.

The effect of speed and load variation on gait and the consequences on energy cost is addressed in a study by Bastien, Willems, Schepens & Heglund (2005), which concludes that the metabolic cost rises with increasing speed (0.5m / S-1.7m/s) and also with increasing load at any of the speeds studied. Also the effect of the gait being or not performed at altitude shows that this variable causes an increase of about 15 beats per minute (bpm) in the mean value of max HR, that there is no significant difference in min HR and that in the average HR there is a difference of about 4 bpm (Nenad, Slobodan, Ćirić, Ranko & Nebojša, 2012).Another factor that is held to have an influence on the energy cost is the gait variation. According to O'Connor, Xu & Kuo (2012) the energy cost increase is mainly due to two reasons: active movement corrections require a muscular effect and; steps variability (width)is more energy-efficient.

However, the emphasis given in the different studies to the factors influencing the individual's performance and their energetic consumption in gait does not allow us to understand the real effect on the individual specially when walking on a terrain with no homogeneous obstacles. Although the influence of terrain instability is addressed in some studies (Voloshina, Kuo, Daley & Ferris, 2013, Voloshina & Ferris, 2015, Davies & Mackinnon, 2017), the costs associated with the need to constantly being aware of the obstacles and the inherent tension to this state of alert, the assembly of adequate strategies to the course and its execution are data that is not yet found on literature.

Despite this, several authors point out the need to consider, in addition to the task-related motor work, the mental or cognitive work (Lundberg, Forsman, Zachau, Ekloèf, Palmerud, Melin & Kadefors, 2002), introducing the concept of workload but focusing their studies on bodybuilding situations.

We consider that in a trail it is so important to consider the factors that influence the physiological effort of the individual (inclination, altitude, type of terrain, etc.) as well as the factors related to the mental or cognitive work that, we believe, may indirectly influence the HR and consequently the energy consumption. On the other hand, the HR variation also affects the individual's own performance, as Robazza et al. (1998) concluded in archery with professional competitors when they observed that the HR slowdown during the execution of the task was indicative of a better functioning of the processes related to the attention in the performance. Already in earlier studies better control of HR has been associated with better performance and higher levels of experience in parachute (Fenz & Jones, 1972).Based on this framework, we aimed with this work to understand the variation caused in HR in a walking situation where the individual is permanently being asked to collect information, interpret it and set up the adequate walking strategies. One of the hypotheses we've tested is that if the process inherent in the need for constant adaptation to the route results in an additional cost for the individual, this cost will be reflected in the HR values during the trail. On the other hand, we also hypothesize that if the cost in terms of motor work and mental / cognitive work are independent, it is natural that not all individuals with better performance in terms of motor costs would also perform better when the task mainly requires mental / cognitive costs.

2. Methods

2.1. Sample

20 individuals aged between 20 and 34 years (mean age 25.1 years), 13 males and 7 females, were used as sample. The test was performed individually, the sample being divided into two subgroups of 10 elements in which each of them started the test for a different situation (situations 1 and 2).Participants were informed about the protocol prior to their participation and signed an informed consent document. The study was carried out in accordance with the ethical requirements.

2.2. Procedures

We've used a treadmill (BH Impulse) where several marks were placed along the matto condition the individual's gait. Each individual performed two situations for 10 min. each, and changed the treadmill speed every 2 min. as follows: 2'-4km/h, 4'-4.5km/h, 6'-3.5km/h, 8'-4.5km/h, 10'-4km/h: In the first situation (1) individuals walked on the treadmill without any conditioning; On the second situation (2) individuals walked on the same treadmill but could not step the marks on the mat. Half of the group (n = 10) started the test by the (1) situation and only after 60 min. rest performed situation (2); the other half (n=10)started with the (2) situation and after 60 min. performed the (1) situation. A HR monitor was used to measure HR every 30s throughout each the test. Each individual experienced walking on the treadmill for 1 min. before starting the test and the data collection to ensure the familiarization with the situation. Before the test, in situation (2), the initial information was reinforced that the individual's concern should be to avoid treading the marks and it was also explained that the individual should not pass a tape placed on the back of the treadmill that defined Safety limits for progression on the treadmill.

2.3. Instruments

A Polar (Rs 300x) was used to measure the HR of each participant in each 30s of the two situations carried out on the treadmill (BH Impulse). Statistical analyses were performed with IBM SPSS Statistics version 22.0 mainly using descriptive statistics.

3. Results

Between the two situations (1 -without any conditioning and 2 - walking without steping the marks) there was an increase in HR mean of 44 bpm(+42%).The maximum HR value for the unconditioned test (1) was 139bpm and the minimum value was 70bpm.For the situation where individuals could not step on the marks (2) the maximum HR value was 185bpm and the minimum value of 96bpm.

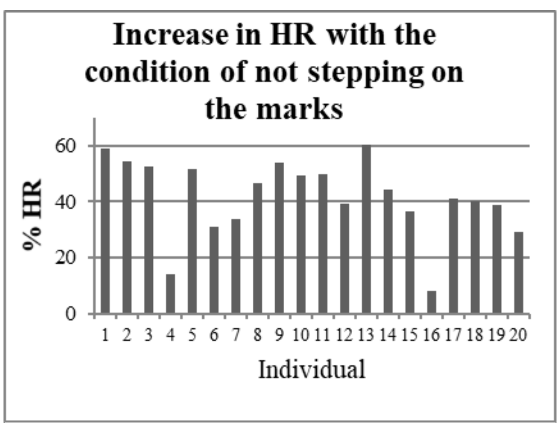

Fig. 1 – Increase in HR (%) in the situation with the condition of not stepping on the marks

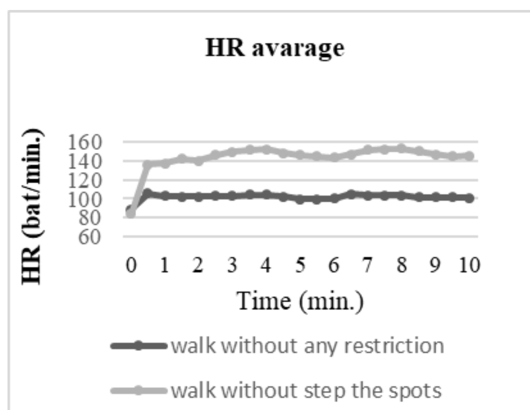

Fig. 2 – HR value (bat / min) in both situations.

The highest average variation between the two situations occurred from minutes 2 to 4 and from minutes 6 to 8, intervals where the velocity was 4.5 km/h; however there was a very small difference (2 bpm) relative to the intervals from 4 to 6 min. and from 8 to 10 min. where the speeds were lower 3.5 km/h and 4km/h correspondingly. Only in the range of 0 to 2 min. a lower variation of the HR (36 bpm) was perceptible.

In the unconditioned situation (1) the mean HR of the sample showed practically no variation with the change in velocity, since with the conditioning of not steping the marks (2) a slightly higher variation was visible according to the data in table 1.

Table 1.

Mean heart rate for the different velocities in the two situations.

	0-2 min. 4Km/h	2-4 min. 4,5Km/h	4-6 min. 3,5Km/h	6-8 min. 4,5Km/h	8-10 min. 4Km/h
Walking without conditioning	103 bat/min.	104 bat/min.	101 bat/min.	104 bat/min.	102 bat/min.
Walk without treading the marks	139 bat/min.	150 bat/min.	146 bat/min.	151 bat/min.	147 bat/min.

Comparing the results of each individual in both situations, it can be seen that the best results in the mean HR of the test performed without conditioning (1) do not correspond to the best results of the test performed with the condition of not steping the marks (2). In the seven individuals who were able to perform the task without conditioning with an average HR lower than 100 bpm the variation for the situation (2) was of 42.4%(slightly higher than the total group average: 42%).

4. Discussion

The results show that the constant need to adapt to the terrain implies a cost that is reflected in the HR values of the individual. Comparing the mean values obtained in this study (42% increase), we verified that it is 3% higher than the average increase obtained with the slope increment in 14% according to the study by Brito, Moreira & Reis (2004).Also other studies analyzing the energy costs of walking and running on uneven ground (Voloshina, Kuo, Daley & Ferris, 2013; Voloshina & Ferris, 2015) found energy costs increases of 27-28%, although they did not a present values obtained at the HR level.

When comparing different types of treads more or less unstable, even in a population accustomed to walking on this type of terrain (grass vs. sand) increases in HR between 16 and 33% are observed (Davies & Mackinnon, 2017). The highest increase in HR (33%) in the previous studies was observed at a speed of 5km/h, a speed that we did not use in our work, but which is very close to the speed that caused a higher HR variation(4.5km/h).

However, in the Davies & Mackinnon, 2017 situations, although in the first case the treadmill floor was uneven and in the second case the characteristics of the sand floor (grass vs. sand) caused in themselves some instability, there was no need for the individuals to choose where to put the feet and make the necessary adjustments in the motor output, and therefore, it seems natural that the need for adaptation is lower than in the situations we've studied.

As mentioned, the gait variation alone causes an increase in the energy expenditure of about 5.9% (O'Connor, Xu &Kuo, 2012). Considering that in addition to the motor work task individuals were exposed to mental/cognitive work due tothe constant need to read the terrain an HR increase was expetable in the study we've conducted as showned.

5. Conclusions

From the collected data we can infer that the need for adaptation in trails requires an additional cost for the individuals that are reflected in HR. However, from individual analysis of data we can also verify that the individuals with better HR values in the test without any conditioning are not the ones that evidence fewer costs in the adaptation to the conditioned situation, which raises some interesting questions when thinking about training for this type of situations. For example, training for these types of situations when a constant reading of the terrain and adaptation is not required seems not to be profitable in this sense. We believe that these results reinforce the importance of considering this factor (decision making) when we intend to prepare individuals for mountain walking activities where adaptation to the terrain is crucial to the success of their performance (like previous studies. eg: Fernando, Lopes & Vicente, 2011), but also the importance of considering it when thinking about the classification of hiking trails, pedestrianism, or walking paths.

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