Correlates of Mood and RPE During Multi-Lap Off-Road Cycling

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Correlates of Mood and RPE During Multi-Lap Off-Road Cycling

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Abstract This study examined the relationship between mood and rating of perceived exertion (RPE) during a simulated multiple-lap time trial (MLTT). Nineteen male cyclists performed a MLTT consisting of four 9.9 km laps, each lap with a gradient ranging from 0 to 10 %. Mood as measured by the Profile of Mood States Questionnaire (POMS) and perceived exertion as measured by the Borg CR100 scale (RPE) were obtained at the end of each lap. A categorical multiple regressive model, having median of POMS subscales as independent variables, was obtained to explain the variance in median RPE responses. Increases in POMS fatigue scores and decreases in POMS vigour scores were observed throughout the MLTT ($P < 0.001$). A linear increase in RPE during the MLTT was also observed ($P < 0.001$). POMS fatigue subscale scores accounted for 88 % of the variance in RPE during the MLTT ($R^2 = 0.88$, $P = 0.002$), and no other POMS subscale improved the final predictive model. With the exception of fatigue these results suggest that most aspects of mood do not have a discernable effect on RPE during a MLTT. The rate of increase in RPE can predict the MLTT endpoint.

Keywords Pacing strategy · Mood state · Exercise regulation · Exercise performance · Mountain bike

Introduction

The purpose of a pacing strategy during an athletic event is to regulate performance and prevent the occurrence of premature fatigue (Abbiss and Laursen 2008; Roelands et al. 2013; Gibson et al. 2006). It has been suggested that the pacing strategy is affected by a variety of factors including physiological factors such as metabolic rate and core temperature (Tucker et al. 2006), and psychological processes such as mood (Parry et al. 2011), ratings of perceived exertion (RPE) (Baron et al. 2011), presence of competitors (Corbett et al. 2012), previous experience (Foster et al. 2009; Mauger et al. 2009) and knowledge of the exercise endpoint (Baden et al. 2004). Furthermore, the

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pacing strategy is suggested to be continuously adjusted during an athletic event due to alterations in peripheral physiological systems (Gibson et al. 2006) and RPE (Noakes 2004; Tucker 2009).

The RPE was suggested as a key parameter for the continuous adjustments in pacing, thus athletes would alter their pace to maintain an RPE trajectory and match maximal RPE values to the exercise endpoint (Noakes 2004; Eston et al. 2007; Tucker 2009). For example, in closed-loop self-paced exercise an increase in RPE that is too steep is thought to trigger a down regulation of pacing, thus avoiding premature fatigue before the exercise endpoint. According to this suggestion athletes set an expected RPE based on the prior experience and knowledge of the exercise endpoint so that any mismatch between actual and expected RPE triggers a change in pacing strategy (Gibson et al. 2006; Tucker 2009). The fact that RPE increases linearly in a multidiscipline race as an Ironman triathlon, even though re-settings at the start of every different discipline (Parry et al. 2011), may indicate the robustness of the RPE to adjust pacing and predict the exercise endpoint in closed-loop self-paced exercises.

It has been suggested that RPE is affected by physiological and psychological factors. Physiological responses such as alterations in heart rate (HR), oxygen uptake (VO_2), glucose, dopamine and noradrenaline plasma concentrations (Pires et al. 2011), as well as psychological responses such as alterations in emotions appear to affect RPE during exercise (Baron et al. 2011; Micklewright et al. 2009). Regarding the psychological responses, alterations in emotional state can influence the interpretation of how hard the exercise has been perceived (Baron et al. 2011; Parry et al. 2011). In fact, previous study demonstrated that changes in RPE were matched by changes in affect scores during 20-min exercise bouts (Baden et al. 2004). However, which specific emotions would affect RPE during exercise have not been well understood.

Study by Parry et al. (2011) found that specific changes in mood may be related to changes in RPE. This study showed that mood disturbances such as tension and fatigue occurred before and after a multidiscipline race. However, it was not possible to know if these specific mood disturbances would have affected RPE along the race, as mood state measures were obtained before and after, rather than during the race. Therefore, given the role of RPE as a determinant of pacing strategy studies are required to investigate the RPE and mood disturbance relationship during exercise.

The aim of this study was to describe the mood disturbance and RPE responses during exercise. We were especially interested to understand which specific alterations in mood disturbance may be correlated with RPE responses during a multiple-lap time trial (MLTT). Our hypothesis was that RPE would be influenced by increases in mood disturbances along the MLTT due to increased feelings of tension and fatigue, but decreased feelings of vigour (Micklewright et al. 2009). We further hypothesized that the rate of increase in RPE would accurately predict the MLTT endpoint whatever have been the mood disturbances.

Method

Participants

Nineteen male mountain bike cross country (XCO) cyclists volunteered to take part in this study, after study's advertisement in official competitions. All participants were well-trained cyclists with experience in competitions at regional and national level. They had training frequencies of 6 days per week for at least 5 years when the study was conducted. The characteristics of the athletes are show in Table 1.

Participants with record of recent injuries or any physical problem that limited to take part in competitions were not included in the study. The athletes were informed about all experimental procedures, risks and benefits when they filled the consent form. Their physical test outcomes were available after the study's termination. All procedures were approved by a local Ethics Committee for Human Research.

Experimental Design

Participants visited the laboratory on three sequential sessions: (1) to obtain anthropometric measurements and perform a maximal incremental exercise test; (2) to

Table 1 Physical and physiological characteristics of mountain bike (XCO) cyclists

Variables	Total (n = 19) Mean ± SD
Age (years)	32.2 ± 6.5
Body mass (kg)	67.8 ± 6.5
Height (cm)	174.9 ± 5.4
Body fat (%)	7.3 ± 2.9
$W_{máx}$ (W)	295.8 ± 21.1
VO_{2max} (mL kg^{-1} min^{-1})	65.3 ± 4.9
LT (W)	214.9 ± 25.1
OBLA (W)	259.8 ± 27.7

Values are mean ± SD

Wmax (W) power output at VO_{2max}, *LT (W)* power output at the lactate threshold, *OBLA (W)* power output at the onset of blood lactate accumulation familiarize themselves with the MLTT; (3) and to perform a MLTT while mood state and RPE responses were obtained. A laboratorial MLTT was used in order to allow mood state measures along the exercise. The sessions were performed on different days interspersed by a 48 h minimum interval. All tests were performed in a temperature-controlled room of 21 ± 1 °C at the same time of the day (≈2 h). Participants were recommended to avoid ingesting solid food for at least the 3 h before each test, as well as caffeine or alcohol for the last 24 h before the tests. They were further recommended to avoid high-intensity exercise for the last 48 h before the tests. Throughout the trials participants were permitted to consume water ad libitum (Rose and Peters-Futre 2010).

Procedures

Visit 1

Measures of body mass, height and seven skinfolds were performed according to the International Society for the Advancement of Kinanthropometry—ISAK (Norton and Olds 1996; Slim Guide, Rosscraft, Surrey, Canada), thereafter the body fat percentage was estimated according to Jackson and Pollock's and Siri's equation (Jackson and Pollock 1978; We 1961).

After anthropometric measures participants were accommodated on the bicycle while pedals and saddle were adjusted according to the individual's preference. Thereafter they performed a 10 min warm-up with intensity set at 100 W, and began a maximal incremental cycling test immediately. The initial intensity was set at 100 W and 30 W increases were performed every 5 min until exhaustion. Participants were verbally encouraged to push themselves as long as possible, and the exhaustion was defined as a drop in pedal cadence below 70 rpm.

The test was performed on a road bicycle fixed to an electromagnetically braked cycle-simulator (Computrainer™ Lab 3D, RacerMate, Seattle, WA, USA). Throughout the incremental exercise test, participants wore a mask (Hans Rudolph, USA) connected to an open-system gas analyzer for gaseous exchange measurements (Vacumed Vista-Mini CPX metabolic analyser, Ventura, CA, USA). Both the cycle-simulator and gas analyser were calibrated before every test, according to manufacturer's specification. The peak of oxygen uptake (VO_{2peak}) was determined by the highest 30 s value of VO_2 reached during the last stage of the maximal incremental exercise test (Weston et al. 2002), while the peak power output (W_{ppo}) was calculated as the highest power recorded at the last complete stage. When necessary the W_{ppo} was corrected by the time sustained in incomplete stage (Kuipers et al. 1985). Throughout the test HR was monitored continuously (Polar® RS 800 CX, Polar Electro, Oy, Finland) while RPE was obtained at the end of each stage according to the Borg's CR100 scale (Borg and Borg 2002; Borg and Kaijser 2006).

Visit 2

Participants were familiarized with equipments and the MLTT, thus allowing them to be familiarized with the task and create a free pacing strategy (Foster et al. 2009; Tucker 2009). A computer monitor was placed in front of the participant and an integrated 3D software (RacerMate Inc. Version 1.0) was used to simulate a multiple-lap course, providing information of speed, power output, cadence and distance completed. To resemble a real competition the integrated 3D software used participants' body mass and different gradients to determine speed and power output along the trial. Participants were encouraged to complete the MLTT "as fast as possible", before the test's commencement.

During the familiarization session the POMS scale was carefully explained. In order to counteract potential response bias associated with repeated POMS trials (pre-race, lap-by-lap and post-race reports), participants were instructed to complete the POMS questionnaire as honestly as possible, based on their feeling at the exact moment of the POMS filling, rather than based on previous feelings that they may have remembered.

Visit 3

Immediately after a 10 min warm-up at 100 W the experimental MLTT started. The MLTT consisted of four laps with a 9.9 km course and 0–10 % elevation determined stochastically. The athletes were instructed to complete the MLTT "as fast as possible" and to maintain the pacing strategy created in the familiarization session. The mean power output, RPE and mood responses were recorded for every lap, and mood reposes were additionally obtained before and after the MLTT.

Mood Questionnaire

Mood state was measured by a shortened "right now" version of the Profile of Mood States Questionnaire (POMS) translated to Portuguese (Viana et al. 2001). The POMS is a psychological rating scale used to measure the severity of transient, distinct changes in mood through 36 single-word mood descriptors graduated with a 5-point Likert scale. These descriptors score six subscales: tension, depression, anger, vigour, fatigue and confusion. Large internal consistence (expressed as Cronbach α) has been reported for tension ($\alpha = 0.75$), depression ($\alpha = 0.88$), anger ($\alpha = 0.85$), vigour ($\alpha = 0.88$), fatigue ($\alpha = 0.91$) and confusion ($\alpha = 0.72$), with minimum and maximal values ranging between 0–23, 0–22, 0–22, 0–20, 0–22, 0–20 and 84–186, respectively (Viana et al. 2001). Although POMS is frequently used for clinical proposals, its use in exercise routines is promising (Nyenhuis et al. 1999).

The POMS questionnaire was completed immediately before the MLTT, between the 8th and 9th km of every lap, and 30 min after the MLTT. To record the POMS scores during the MLTT an evaluator filled the questionnaire according to the participant's answers.

Data Analysis and Statistics

Median of POMS and RPE data obtained during the MLTT (lap 1 to lap 4) was calculated. Thereafter, categorical multiple regressive models having POMS subscales such as tension, anger, fatigue, depression, confusion and vigour, as well as the total mood disturbance (TMD) were obtained to explain the variance in RPE. Based on R^2, partial correlation, and tolerance criteria the final predictive model that best accounted for the variance in RPE was obtained (Hair 1998). Predictive models were obtained only when moderate to large effect size (ES; expressed as η^2) and power were reached. Additionally, a repeated measures Friedman ANOVA was carried out over POMS data recorded during MLTT, while Wilcoxon's test compared POMS data recorded before and after the MLTT.

Furthermore, the slope of the RPE-distance relationship was calculated. In order to allow comparisons with previous study that have analyzed RPE slope data with parametric statistics (Baron et al. 2011; Pires et al. 2011) the correlations between RPE slope and mean power output in MLTT (W_{MLTT}) or RPE and distance covered in every lap were determined by Pearson's coefficient test. Time main effects on power output and RPE were verified by ANOVA one-way. Statistical significance was set at $P < 0.05$ in all analysis, results were reported as mean ± standard deviations.

Results

Mood Disturbances During the MLTT and Their Effects on RPE

We found an increase in TMD ($P < 0.001$, $\eta^2 = 0.99$) and POMS subscale of fatigue ($P < 0.001$, $\eta^2 = 0.99$), but a decrease in vigour during the MLTT ($P < 0.001$, $\eta^2 = 0.99$). There were no differences in POMS subscale for tension, anger, confusion and depression during exercise. Table 2 shows mood responses to the MLTT in arbitrary units.

Categorical multiple regressive models having fatigue as predictor variable accounted for 88 % of the variance in RPE during the MLTT. Neither other POMS subscales nor TMD improved the final predictive model. Therefore, a final predictive model with large ES and power, composed of fatigue scores was able to explain most of the RPE variance (Table 3).

Mood Disturbance Before and After the MLTT

Despite no difference in tension, anger, confusion and depression measures obtained before and after the exercise, there was a significant increase in fatigue ($P < 0.001$) and decrease in vigour when comparing pre to post-exercise values ($P < 0.001$).

Table 2 Mood responses to MLTT

POMS subscale	Pre-race		Lap 1		Lap 2		Lap 3		Lap 4		Post-race		Sig
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	*P*
Tension	4	3	4	4	4	5	4	4	5	6	3	3	0.503
Anger	0	2	1	4	1	4	2	5	2	5	1	3	0.054
Fatigue	2	2	5	3	7	4	10	5	12	6	7	5	<0.001
Depression	0	2	1	3	1	3	2	4	1	4	1	2	0.069
Confusion	4	2	4	3	4	3	5	3	6	5	4	3	0.093
Vigour	15	4	14	5	14	5	13	5	11	6	13	6	<0.001
TMD	97	13	103	19	106	21	111	23	117	30	105	20	<0.001

POMS subscale of Fatigue and TMD increase ($P < 0.001$), and subscale of Vigour decrease ($P < 0.001$) during MLTT

M mean, *SD* standard deviation, *TMD* total of mood disturbance

Rate of Increase in RPE as Predictor of the MLTT Endpoint

The average time to complete the total MLTT was 102 ± 7.23 min. Decreases in W_{MLTT} (Fig. 1) was observed from lap 1 (260.5 ± 26.5 W) to lap 4 (213.6 ± 32.2 W) ($P < 0.001$, $\eta^2 = 0.66$). There was a linear increase in RPE throughout the MLTT (Fig. 2) ($P < 0.001$, $\eta^2 = 0.99$), thus a nearly perfect correlation between either the RPE slope and the distance covered (r = 0.9, $P < 0.001$) (Fig. 3), or the RPE slope and the W_{MLTT} (r = −0.971, $P = 0.028$) was observed (Fig. 4).

Table 3 Final regressive model of the median RPE responses during MLTT

Predictor	R^2	APR	bSTD	*P*	ES	Power
Fatigue	0.88	0.12	0.94	0.002	0.87	1.0

APR means apparent prediction error, *bSTD* is the beta standardized coefficient, *ES* is the effect size of the model expressed as η^2

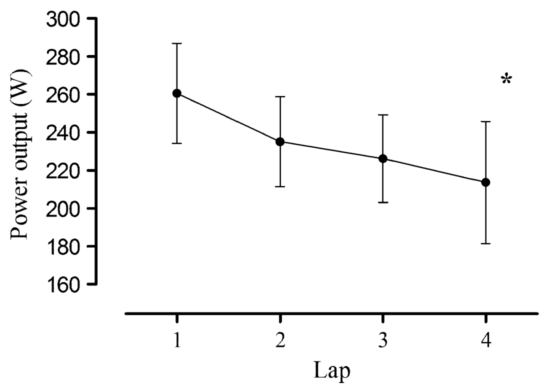

Fig. 1 Mean power output during the MLTT. *Asterisks* indicates time main effect between laps *2*, *3* and *4*, and between laps *1* and *4* ($P < 0.05$)

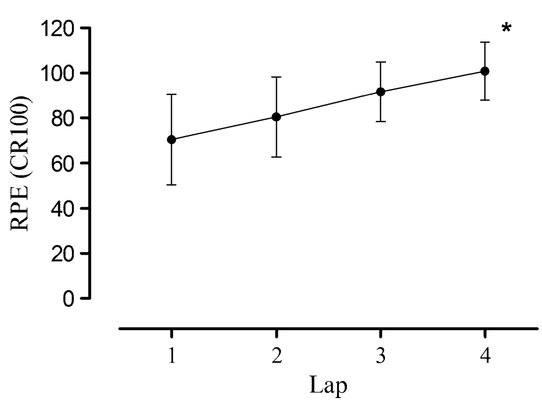

Fig. 2 Mean RPE during the MLTT. *Asterisks* indicates time main effect between laps *3* and *4*, and between laps *1* and *2* ($P < 0.05$)

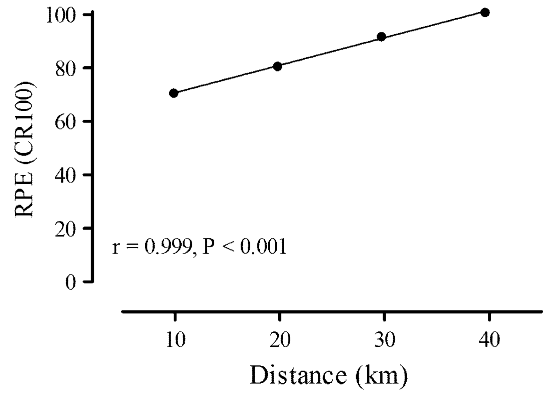

Fig. 3 Median RPE responses as a function of the distance covered in the MLTT

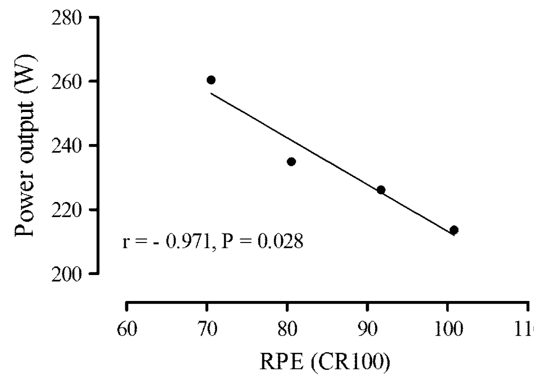

Fig. 4 Mean power output responses as a function of the RPE

Discussion

The principal finding of this study was that changes in fatigue as measured by the POMS questionnaire, explained most of the variance in RPE responses during a MLTT. In addition, we further provided support to results of multi-discipline race (Micklewright et al. 2009), as the rate of increase in RPE predicted the MLTT endpoint regardless of the overall mood disturbances.

Mood Disturbances During the MLTT and Their Effects on RPE

Some studies have acknowledged that fatigue is a sensation derived from a complex and integrative system of sensorial feedback that is responsible to maintain homeostasis during exercise (Gibson et al. 2003, 2006; Gibson and Noakes 2004; Tucker 2009). Based on this interpretation our results provide some evidence that fatigue is the main affective component of the perceived exertion, as fatigue was the only POMS subscale that accounted for RPE variance during the MLTT.

Contrary to our hypothesis, there were no alterations in feelings of tension during the MLTT, although the reduction observed between pre and post-exercise which was consistent with previous results (Micklewright et al. 2009; Parry et al. 2011). In the context of athletic performance, it could be suggested that elevations in feelings of tension may facilitate cycling performance. Particularly, we observed that feelings of fatigue were intensified when participants were close to the end of the MLTT, perhaps toning down other mood states. In fact, athletes progressively shift the mood state during a race, changing from a diffuse multiplicitous affective response to focus on an intense unidimensional affective state of fatigue (Baron et al. 2011).

The results presented in Table 2 give some support for a possible intensified unidimensional affective state, as the increase in TMD during MLTT was related to changes in feelings of fatigue. These results further corroborate suggestion that displeasure sensations are associated with high intensity exercise (Ekkekakis et al. 2011; Kilpatrick et al. 2007). Interestingly, however neither the TMD nor the other POMS subscales had any predictive value in RPE responses during the MLTT. Perhaps, the fact that fatigue sensations are interpreted as a result of integrated sensory feedback may be highlighted (Gibson et al. 2003, 2006; Gibson and Noakes 2004; Tucker 2009), as RPE has been also suggested to be result of a complex interaction between both the physiological and psychological processes (Gibson et al. 2003, 2006). Thus, it is possible that both the fatigue as measured by POMS questionnaire and RPE responses may represent similar psychological and physiological constructs.

Mood Disturbance Before and After the MLTT

When comparisons with pre- and post-race values were performed, it was found that there was an increased TDM in post-race, even 30 min after the end of the MLTT. This mood disturbance may have been due to increased fatigue and decreased vigour sensation over the MLTT. Furthermore, in spite of recovery in vigour sensations between the end of the MLTT and the post-race, these values did not return to pre-race levels. These results are in agreement with mood disturbance results reported in a 73.4 km ultramarathon (Micklewright et al. 2009) in which most participants recovered the overall emotional state only 2 h after the exercise. In that study some participants returned to baseline levels only 4 h after the exercise, suggesting that overall mood state after intense exercises may take long to be completely recovered (Micklewright et al. 2009).

Rate of Increase in RPE as Predictor of the MLTT Endpoint

Fatigue could be interpreted as either a physical or an emotional response which may be evidenced by either a decrease in power output or an increase in perceived exertion over a physical task, respectively (Gibson et al. 2003, 2006). The present study reported both these fatigue responses, as there was a nearly perfect inverse relationship between power output and RPE ($r = -0.971$, $P = 0.028$) during the MLTT. This result corroborates our hypothesis, suggesting that athletes pace themselves in order to avoid premature, physical and emotional fatigue. In this perspective, athletes would pace themselves to achieve their best possible performance, matching the rate of increase in RPE to the exercise endpoint (Tucker 2009). In agreement, we observed that the rate of increase in RPE was significantly correlated with the distance covered and power output in MLTT, regardless of the mood disturbance variations.

Considering that MLTT is multiple lap test, it may be plausible to suggest that athletes paced themselves based on the final MLTT endpoint, rather than on the endpoint of single laps. Thus, at least in a MLTT as used in the present study this finding may indicate the absence of a RPE resetting mechanism as described previously (Parry et al. 2011), although the differences between the multiple lap races used in both studies should be considered with caution.

Conclusion

The present study suggests that fatigue feelings may account for the greatest variance in RPE responses during a MLTT. Other emotions such as vigour, tension, anger, confusion and depression did not enter into the final predictive model, thus suggesting that these emotions may not be incorporated in RPE responses during exercise. Regardless of changes in overall mood state over the MLTT the rate of increase in RPE was correlated with the MLTT endpoint.

Compliance with Ethical Standards

Conflict of interests The authors declare has no conflicting interests.

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