

# STABILITY OF RPE INCREASE DURING REPEATED INTERMITTENT SPRINTS

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The current investigation examined the potential teleoanticipatory effect on perceptual response during repeated bouts of maximal sprint work. To determine the consistency of ratings of perceived exertion (RPE) increase during identical exercise bouts following variable recovery periods, 16 (8 men, 8 women) participants completed four separate trials of repeated maximal sprinting on 4 separate days utilizing different recovery periods. Following completion of the baseline trial, participants were given variable, counter-balanced recovery periods of 24, 48 and 72 hours, whereupon they repeated the intermittent exercise protocol. To determine the degree of similarity among trials, each individual's rate of RPE progression during each cycle of eight sprints throughout the recovery trials were compared to the rate of progression during the baseline exercise session. A series of 4 (trial) × 3 (cycle of sprints) repeated measures ANOVA were performed to identify significant main effects between trials and among cycles while session RPE was analyzed using one-way repeated measures ANOVA. Fisher's least significant difference post-hoc procedures were performed to identify where significant differences occurred when appropriate. Results revealed an inconsistency in the stability of RPE across repeated bouts of sprint exercise, with at least 50% of individuals having a substantial difference in RPE (i.e. ± 1 unit change) in at least one subsequent trial. These variations in perceptual responses were observed despite a concomitant stability of physiological and performance responses between sessions. Results suggest that rate of RPE increase correspond more closely to increased or decreased physiologic strain than to an anticipatory, feed-forward mechanism following variable recovery durations. [*J Exerc Sci Fit* • Vol 8 • No 1 • 1–10 • 2010]

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## Introduction

Ratings of perceived exertion (RPE) are commonly utilized as a practical, noninvasive adjunct when monitoring physiological and psychological markers of

impending fatigue during exercise (Borg 1998; Noble & Robertson 1996). The utility of monitoring RPE during exercise has clear advantages from a practical standpoint as it eliminates the need for invasive blood draws or cumbersome testing equipment. Perceptual measures also have the advantage of being related to multiple physiological variables such as heart rate, ventilation, oxygen uptake, blood lactate concentration and core temperature, thus allowing a researcher or coach to expeditiously and indirectly, yet accurately, monitor both the psychological and physiological state of the



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individual (Crewe et al. 2008; Green et al. 2007, 2006, 2005, 2003).

Typically, increases in RPE have been linked to associated biological consequences that are fed back via sensory input and interpreted by the brain to yield a conscious perception of effort (Robertson & Noble 1997; Mihevic 1981). Consequently, power output is a corollary of the individual's specific physiological and metabolic state that influences the neural adjustments resulting from peripherally-based afferent messages. In these instances, it may be that power output and perceptual response is a reaction to the physiological strain experienced and communicated to the brain. That is, the brain responds in a feedback manner to the constantly changing physiological state of the individual performing a bout of exercise.

There is now emerging evidence supporting the notion of an extracellular regulator of exercise (i.e. teleoanticipation) that mediates perceptual response in a feedforward manner (Faulkner et al. 2008; St Clair Gibson et al. 2006; Lambert et al. 2005; St Clair Gibson et al. 2003; Ulmer 1996). In this model, it is proposed that RPE is subject to a central controller that considers both an individual's current physiological status in conjunction with a subconscious, anticipated level of perceptual strain that is predetermined in order to achieve optimal performance (Joseph et al. 2008; Eston et al. 2007; Lambert et al. 2005). Simply stated, teleoanticipation asserts that an individual's perception of effort is a consequence of a subconscious regulation of power output given that an individual is aware of either: (a) the distance (or time) completed or (b) the distance (or duration) of exercise remaining. The teleoanticipatory center is integrative in nature, as it is sensitive to an individual's physiological and psychological state prior to the beginning of each exercise bout. Thus, an individual's initial perceptual response as well as power output should be a calculated response to computations made by the teleoanticipatory center (within the brain) prior to beginning the exercise session (Crewe et al. 2008; Joseph et al. 2008; St Clair Gibson et al. 2006, 2003; Hampson et al. 2001). These adjusted perceptual and power responses allow the participant to complete a bout of exercise to the best of their ability relative to their current physical, mental and nutritional state and not, necessarily, at a level that would be considered optimal in terms of performance (St Clair Gibson et al. 2006, 2003). In this model, power output and RPE are not reactionary variables; rather, they are subconsciously predetermined and allowed to increase only at a rate or under conditions at which

the brain feels the current pace or effort will not overtly threaten homeostasis (Hampson et al. 2001). Under this theory, RPE is proposed to function in a feedforward rather than a feedback manner.

Proponents of this theory have consistently implicated anticipatory regulation of athletic performance in situations where the athlete is aware of either the time remaining to completion or the distance left to be completed. Thus, if an individual is conscious of either of these two variables then performance and perceptual response should, theoretically, be under teleoanticipatory control. While teleoanticipation has been supported by a number of studies involving primarily open-loop (Crewe et al. 2008; Eston et al. 2007) and closed-loop (Faulkner et al. 2008; Joseph et al. 2008; Tucker et al. 2006, 2004; Baden et al. 2004) aerobic type exercise, there remain a remarkable number of sport and exercise specific conditions in which this theory has not been tested. Therefore, the aim of this study was to examine perceptual responses relative to physiological strain and performance outcome of individuals completing repeated bouts of identical intermittent sprinting following varying periods (24, 48 and 72 hours) of recovery. Seemingly, if an individual's rate of increase in RPE is consistent across all trials despite varying recovery levels and, possibly, exercise performance (i.e. sprint time) and physiological strain, it would seem plausible that a central, teleoanticipatory mechanism is responsible for governing exercise performance. Conversely, if RPE is responsive to the corresponding increased or decreased difficulty associated with varying levels of recovery, then it would seem that exercise and, subsequently, perceptual responses are mediated by a feedback rather than a feedforward mechanism. It was hypothesized that individuals performing an intense bout of exercise following shorter (*vs.* longer) recovery periods would produce inconsistent RPEs, indicating increased psychological strain, when concomitantly presenting increased physiological strain.

## Methods

### *Participants*

Sixteen (8 men, 8 women) participants provided written informed consent prior to testing in accordance with the local institutional review board. All individuals were at least moderately active (assessed via questionnaire) and participated in intermittent high-intensity work at least once a week. Prior to data collection, all individuals were assessed for height (m) and body

mass (kg) using a calibrated stadiometer and beam scale, with body fat percentage estimated utilizing the three-site method (men: chest, abdomen, thigh; women: tricep, iliac, thigh) (Pollock et al., 1980) by a pair of Lange skinfold calipers (Cambridge Scientific Industries, Cambridge, MD, USA). All participants arrived at the university recreational fields at least 3 hours post-absorptive and were instructed to be adequately hydrated, to abstain from caffeine at least 4 hours and alcohol 24 hours prior to each testing session. Also, participants were instructed to eliminate any structured exercise bouts (except for the experimental trials) throughout the data collection period, which lasted a total of 6 days. Each individual was asked to report any previously-existing illness, injury or any other physical/emotional issue that would hinder their performance. Criteria for exclusion from the study involved the acknowledgment or observed evidence of any medical or orthopedic problem severe enough to disrupt the individual's performance or endanger his/her health or a self-reported fitness classification below moderately active.

### Experimental procedures

To determine the consistency of the rate of RPE increases during identical exercise bouts following variable recovery periods, each participant completed four separate trials of repeated maximal sprinting on 4 separate days utilizing different recovery periods. Each subject completed a familiarization trial that consisted of three cycles of eight repetitions of 30-m repeated sprints (Figure 1) at least 1 week prior to beginning the experimental trials; however, no perceptual, performance, or physiological data were collected. Each participant's foot position, as an individual preference, was recorded during the familiarization session and replicated throughout the trials. All participants had prior

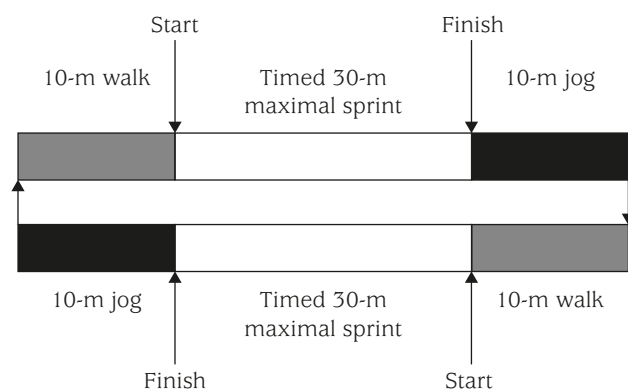


Fig. 1 Schematic illustration of the 30-m intermittent sprints.

experience using perceptual measures during exercise and/or sport training programs.

Following familiarization, participants completed a baseline trial and three subsequent trials of repeated maximal sprint exercise. All testing took place outdoors on a level, grass, playing surface during the Autumn months in the southeastern United States. Prior to each exercise trial, the environmental conditions were assessed in order to ensure similar conditions across all trials. The intermittent exercise protocol consisted of three cycles of eight (total of 24 sprints) 30-m sprints and was conducted on 4 separate days with each trial being separated by 24, 48 or 72 hours following each previous bout. The recovery periods were assigned in a counterbalanced order after completion of the baseline trial. This protocol of assessing recovery after fatiguing exercise has been utilized in previous work (Jones et al. 2006; McLester et al. 2003).

The protocol of the 30-m intermittent sprints as well as the total exercise session protocol is detailed in Figures 1 and 2, respectively. On each testing day, participants arrived at the same time of day and performed a warm-up that consisted of ~300-m of light running followed by two practice repetitions of the 30-m intermittent sprint and 5 minutes of dynamic stretching exercises (e.g. high-knee, carioca). Following the warm-up, participants performed three cycles of intermittent sprinting. Each cycle consisted of eight maximal sprints of 30 m (Figure 1) consisting of an electronically-timed 30-m maximal sprint (Speed Trap II wireless timing system; Power-Systems Inc., Knoxville, TN, USA) followed by a 45-second recovery period that incorporated a 10-m "easy" jog (i.e. deceleration) followed by a 10-m walk with the remainder of the recovery period being passive. After each 45-second rest period, participants were prompted to immediately perform another sprint. Participants were instructed to approach the line 10 seconds prior to initiating each sprint and were given a 5-second countdown to signal the start. The infrared timing system was set at an appropriate lower-leg height, as per the manufacturer's instructions, and was used to record

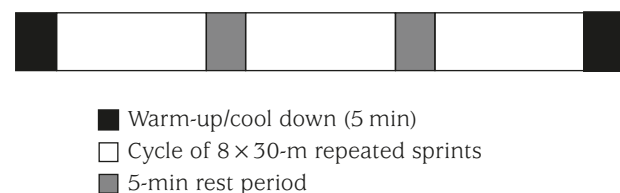


Fig. 2 Schematic illustration of the repeated sprint exercise session.

the duration to the nearest hundredth of a second for each 30-m maximal effort sprint.

As shown in Figure 2, participants were given a 5-minute rest period after completing each set of eight sprints. Prior to initiating each sprint, an RPE using the OMNI scale (Utter et al. 2004) was recorded. An individual reporting increasing RPEs throughout a trial would indicate increased perceptual strain. Heart rate was observed prior to and immediately following each sprint utilizing a Polar heart rate monitor (Polar Electro Oy, Kempele, Finland) that the subject wore throughout each trial. Following the completion of each cycle of eight sprints, each individual's blood lactate concentration was assessed using capillary blood samples taken from the fingertip and analyzed using an enzymatic portable lactate system (Lactate Pro; Arkray Inc., Kyoto, Japan), which has been validated (Saunders et al. 2005). The system was calibrated in accordance with the manufacturer's instructions prior to each trial. In general, an increase in heart rate as well as blood lactate concentration would indicate higher physiological strain incurred by the individual throughout the exercise session. Also, participants were asked to provide a session RPE (S-RPE) using the OMNI scale to rate the global difficulty of the exercise bout (Foster et al. 2001) approximately 20 minutes following each trial. Similar to a RPE, a higher S-RPE would indicate that the individual perceived the trial as more difficult relative to a lower S-RPE score.

In order to determine the rate of fatigue, a decrement score, which was calculated as a percent, was determined for each cycle of each trial. The decrement score was calculated by dividing the difference between the average sprint time (AST) of the cycle and fastest sprint time (FST) of the cycle by the FST of the cycle and multiplying by 100. For example, if a participant had an AST for Cycle 1 of 4.95 seconds and their FST was 4.55 seconds, then the decrement score for Cycle 1 would be 8.1%  $[(4.95 - 4.55)/4.55 \times 100]$ . That is, during the first cycle of eight sprints, this individual's sprint performance declined ~8% from their optimal performance (i.e. FST). Thus, a lower decrement score would be indicative of a lower rate of fatigue while a higher decrement score indicates a higher rate of fatigue during the cycle. While the validity of any measure assessing sprint ability is questionable, this particular measure of a decrement score has been advocated as a more reliable measure in determining decreases in performance during sprint type exercise, reporting a coefficient of variation of <2.7% versus 11–50% observed for other, traditional measures of fatigue index (Oliver 2009).

### Statistical analyses

For each participant, an average RPE for each cycle of eight sprints was calculated for each trial completed. Thereafter, the difference between the average RPE values during the three cycles of sprints during the baseline trial and the average RPEs of each cycle of eight sprints for the 24-hour ( $\Delta RPE_{24}$ ), 48-hour ( $\Delta RPE_{48}$ ), and 72-hour ( $\Delta RPE_{72}$ ) recovery trials were calculated. The rate of RPE change, then, for each individual was investigated. A one-unit change of RPE (i.e. 10%) between corresponding cycles of different trials was adopted *a priori* as a meaningful difference. Thus, a 10% unit change among trials (when compared to baseline) would suggest that the rate of RPE change was not similar between trials under variable recovery conditions.

A repeated measures ANOVA was performed to identify any significant differences among air temperature, wind speed, and relative humidity across all four trials. Additionally, a series of 4 (trial)  $\times$  3 (cycle of sprints) repeated measures ANOVA were performed to identify any significant main effect for RPE, heart rate, blood lactate concentration, total sprint time, and decrement score. S-RPE was analyzed using one-way repeated measures ANOVA. Where appropriate, Fisher's least significant difference post-hoc procedures were performed to identify where significant differences occurred. Effect sizes ( $\eta^2$ ) and statistical power (N – B) were also calculated and are presented with the data. All data are reported as mean  $\pm$  standard deviation. Statistical significance was determined *a priori* at the 0.05 level. All data were analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA).

## Results

### Individual RPE data

The descriptive data for all participants are shown in Table 1. Each individual's mean RPE and their respective  $\Delta RPE$  values during each cycle of eight sprints across all four trials (baseline, 24 hours, 48 hours, and 72 hours of recovery) with a summary of the relative stability and instability of perceptual response across all cycles and trials are shown in Table 2. Ultimately, out of 144 RPE values observed during the recovery trials (24, 48 and 72 hours), there were a total of 48 (33.3%) unstable ( $\pm 1$  unit change) with 96 (67.7%) stable when compared to baseline values. Overall, nine of the 16 participants (56.3%) reported variable RPE values in at least one cycle during a recovery trial (i.e. 24, 48 and 72 hours) relative to their corresponding baseline trial value. Four

**Table 1.** Descriptive characteristics of the 16 participants

Variable	Men (n=8)	Women (n=8)
Age (yr)	23.4±2.5	21.8±1.0
Height (m)	1.8±0.1	1.6±0.1
Body mass (kg)	89.1±26.5	60.7±7.1
Body fat (%)	14.0±4.7	16.6±1.9

of these individuals (25%) produced inconsistent RPE values during at least two or more cycles of sprints during the 24-, 48- and 72-hour trials while only one individual reported unstable RPE values across all cycles and trials when compared to the baseline trial.

### Environmental conditions

Results from the repeated measures ANOVA revealed no significant differences among trials for air temperature (baseline trial, 14.1±5.9°C; 24 hours, 15.1±6.4°C; 48 hours, 12.7±5.9°C; 72 hours, 15.7±6.7°C;  $p=0.20$ ), humidity (baseline trial, 59.3±24.8%; 24 hours, 47.4±22.9%; 48 hours, 52.6±24.9%; 72 hours, 52.9±25.7%;  $p=0.49$ ) or wind speed (baseline trial, 8.9±7.7 km·hr<sup>-1</sup>; 24 hours, 12.1±11.6 km·hr<sup>-1</sup>; 48 hours, 9.5±10.9 km·hr<sup>-1</sup>; 72 hours, 14.1±12.4 km·hr<sup>-1</sup>;  $p=0.56$ ).

### Group data

#### RPE

The average RPE response for the group across all trials and cycles are shown in Figure 3A. Results from the repeated measures ANOVA revealed no significant main effect between trials for RPE ( $p=0.24$ ); however, a significant main effect was found between cycles of sprints for RPE ( $p<0.01$ ;  $\eta^2=0.82$ ;  $N-\beta=1.0$ ). Post-hoc measures revealed a significant increase in perceptual response between Cycle 3 when compared to both Cycle 2 ( $p<0.01$ ) and Cycle 1 ( $p<0.01$ ). Cycle 2 RPE values were also significantly higher than Cycle 1's ( $p<0.01$ ).

#### Heart rate

Figure 3B shows the average heart rate response of the group during all three cycles within each trial. A repeated measures ANOVA revealed no significant main effect between trials for heart rate ( $p=0.63$ ). A significant main effect was found, however, during the trials between the three cycles of repeated sprints ( $p<0.01$ ;  $\eta^2=0.45$ ;  $N-\beta=0.95$ ). The post-hoc analyses revealed a significant increase during Cycle 3 versus Cycle 2 ( $p<0.01$ ) and Cycle 1 ( $p<0.01$ ), with Cycle 2 also significantly higher than Cycle 1 ( $p<0.01$ ).

**Table 2.** Summary of the stability of perceptual response across three cycles of eight maximal sprints following 24, 48 and 72 hours of recovery

	24 hr		48 hr		72 hr	
	Stable	Unstable	Stable	Unstable	Stable	Unstable
Cycle 1	9	7	10	6	11	5
Cycle 2	13	3	10	6	8	8
Cycle 3	14	2	10	6	11	5
Total	36	12	30	18	30	18

Stable=change in rating of perceived exertion < 1 unit when compared to baseline; Unstable=change in rating of perceived exertion > 1 unit when compared to baseline.

### Blood lactate concentration

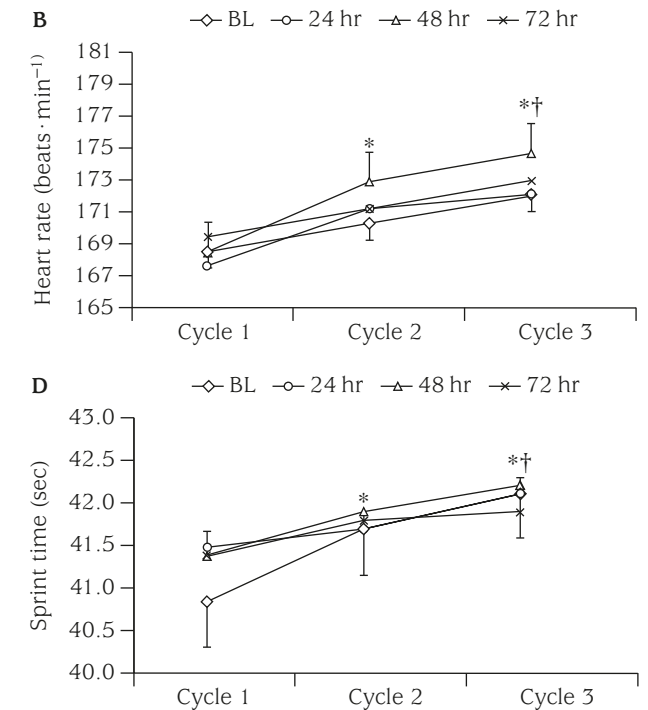
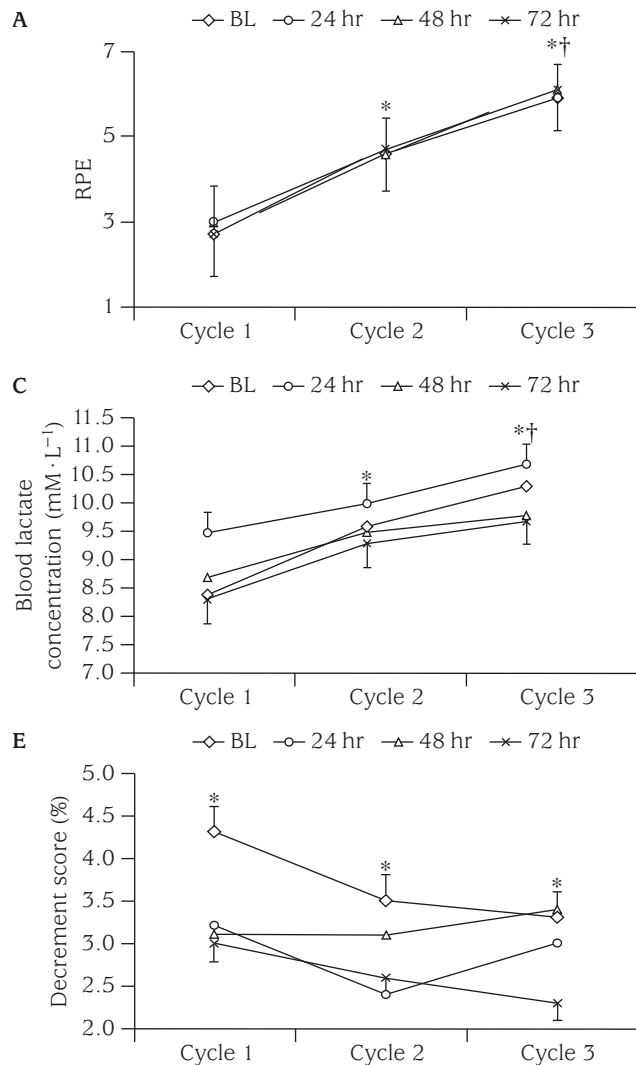
The average blood lactate concentration values observed during all trials and across all cycles are modeled in Figure 3C. Results from the repeated measures ANOVA identified no significant main effect between trials ( $p=0.17$ ). However, a trend emerged revealing higher blood lactate concentration in shorter recovery trials (i.e. 24 hours and 48 hours) relative to baseline, while the 72-hour trial produced the lowest blood lactate concentrations. Within trials, there was a significant main effect found between cycles of sprints ( $p<0.01$ ;  $\eta^2=0.61$ ;  $N-\beta=0.97$ ). Post-hoc analyses showed that blood lactate concentration significantly increased with each successive cycle of sprints within the trials, as Cycle 1 was significantly lower than Cycle 2 ( $p<0.01$ ) and Cycle 3 ( $p<0.01$ ). Additionally, Cycle 2 values were significantly lower ( $p=0.04$ ) than those observed during Cycle 3.

### Total sprint time

Average total sprint times for each cycle observed during all four trials are modeled in Figure 3D. Results from the repeated measures ANOVA revealed no significant main effect between trials for sprint time ( $p=0.68$ ). A significant main effect was found between cycles of sprints for sprint time ( $p<0.01$ ;  $\eta^2=0.62$ ;  $N-\beta=1.0$ ). There was a significant difference in total sprint time observed between cycles, with Cycle 3 producing significantly slower sprint times than both Cycle 2 ( $p<0.01$ ) and Cycle 1 ( $p<0.01$ ), while Cycle 2 times were significantly slower than Cycle 1 times ( $p<0.01$ ).

### Decrement scores

Figure 3E models the rate of fatigue observed for the group during all three cycles of repeated sprint observed during each trial. The results from the repeated measures ANOVA revealed a main effect between trials for



**Fig. 3** Perceptual and physiological response and performance changes during three cycles of repeated sprint exercise measured on four occasions ( $n=16$ ). (A) Ratings of perceived exertion (RPE): \*significantly ( $p < 0.01$ ) greater than Cycle 1; †significantly ( $p < 0.01$ ) greater than Cycle 2. (B) Heart rate: \*significantly ( $p < 0.01$ ) greater than Cycle 1; †significantly ( $p < 0.01$ ) greater than Cycle 2. (C) Blood lactate concentration: \*significantly ( $p < 0.01$ ) greater than Cycle 1; †significantly ( $p < 0.01$ ) greater than Cycle 2. (D) Sprint time: \*significantly ( $p < 0.01$ ) greater than Cycle 1; †significantly ( $p < 0.01$ ) greater than Cycle 2. (E) Decrement in sprint time: \*baseline significantly ( $p < 0.05$ ) higher than the 24-, 48- and 72-hour trials.

decrement score ( $p < 0.01$ ;  $\eta^2 = 0.35$ ;  $N - \beta = 0.91$ ) with post-hoc analyses revealing that decrement scores during the baseline trial were significantly higher than the 24-hour ( $p = 0.02$ ), 48-hour ( $p = 0.02$ ), and 72-hour ( $p < 0.01$ ) trials. There was no difference between the decrement scores during the 24-hour trial versus the 48-hour ( $p = 0.19$ ) or 72-hour trial ( $p = 0.15$ ); however, the 48-hour trial decrement scores were significantly ( $p < 0.01$ ) higher when compared to the 72-hour trial. There was no significant main effect between cycles of sprints for decrement scores ( $p = 0.16$ ) within trials.

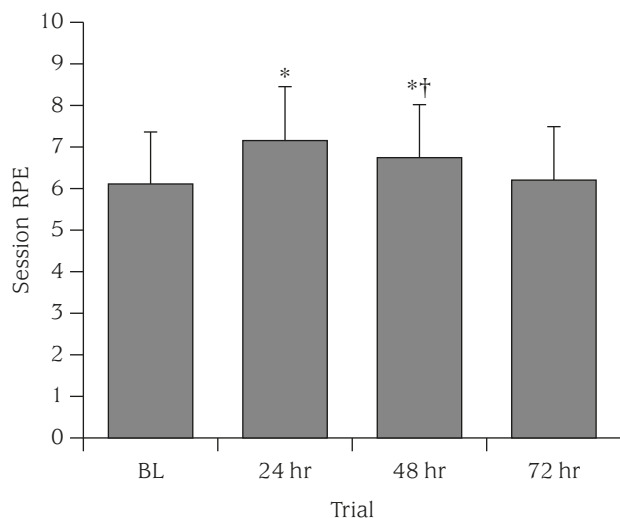
#### Session RPE

A one-way repeated measures ANOVA revealed a significant main effect across trials ( $p < 0.01$ ;  $\eta^2 = 0.40$ ;  $N - B = 0.99$ ) for S-RPE (Figure 4). Post-hoc measures

revealed that: (1) baseline trial was significantly lower ( $p < 0.01$ ) than the 24-hour and 48-hour but not the 72-hour trial ( $p = 0.65$ ); (2) S-RPE after the 24-hour trial was significantly higher than after the 48-hour trial ( $p = 0.03$ ) and 72-hour trial ( $p < 0.01$ ); and (3) S-RPE after the 48-hour trial was significantly higher than after the 72-hour trial ( $p = 0.01$ ).

#### Discussion

The current investigation was designed to examine the potential teleanticipatory effect on perceptual response during repeated bouts of maximal sprint work. Intermittent exercise has become an increasingly popular mode of exercise (Billaut et al. 2003; Balsom et al. 1992) as it



**Fig. 4** Session rating of perceived exertion (RPE) values for each trial of repeated maximal sprinting. \*Significantly ( $p < 0.05$ ) different from baseline (BL) and 72-hour trials; †significantly ( $p < 0.05$ ) different from 24-hour trial.

closely replicates undulating activity patterns and variable energy demands associated with popular team sports such as soccer, basketball, volleyball, and rugby (Billaut & Basset 2007; Price & Moss 2007; Seiler & Sjursen 2004; Billaut et al. 2003; Balsom et al. 1992). Further, individuals routinely participate in day-to-day training without being afforded optimal training recovery (Bishop et al. 2008). Because RPE is a popular tool for monitoring and prescribing intensity and training load (Seiler & Hetlelid 2005; Seiler & Sjursen 2004), it is important to understand the influence of recovery status on perceptual response during identical exercise prescribed at an identical intensity (i.e. maximal). Additionally, because intermittent training is a popular and effective form of training employed by aerobic and anaerobic athletes alike, it serves as an important platform to investigate the possible role teleoanticipation may play during this form of exercise. This is the first investigation examining the possibility of teleoanticipatory regulation not only during repeated intermittent sprint exercise but also in identical training sessions following variable durations of day-to-day recovery.

It is customary for data collected during experimental trials to be analyzed to identify possible differences (or similarities, agreement, etc.) among means. However, in order to best answer the specific research question, an analysis of individual data was considered more appropriate and is consequently a greater focus of the discussion than the analysis of group data. Therefore, a pragmatic approach was taken to analyze each individual's data

in order to observe the rate of change in RPE during identical exercise following variable recovery durations. The primary finding from this study was the overall instability of subjective perceptual strain experienced (i.e. RPE) throughout multiple bouts of repeated sprint work despite no significant changes in physiological responses or performance output. Seemingly, this creates somewhat of a paradox as this does not universally support either a feedback or feedforward mediated model governing RPE. In these instances where no one theory tends to be overwhelmingly supported by the data, a presentation of plausible explanations implicating both feedback and feedforward mediators of perception of effort should be employed. While this approach may seem protracted and somewhat ambiguous, it allows for greater inference towards the identification of possible factors that may be tied to and, ultimately, impact perceived exertion during human performance (Laurent & Green 2009).

Accordingly, one would expect that in order for feedback to be confirmed, an increase in RPE and S-RPE would have been concomitant with increases in physiological strain. It would also be plausible to observe decreases in power output under conditions designed to permit inadequate recovery (24 and 48 hours) with values returning to baseline by the 72-hour trial and results matching those seen in the baseline trial. Likewise, for a feedforward system to be confirmed, RPE responses would remain consistent in the presence of diminished power output and attenuated physiological strain or decreased sprint time (i.e. increased power) with gains in physiological strain in situations where participants experienced a diminished feeling of perceived effort (Joseph et al. 2008). As can be seen in the summary of the individual data regarding the relative stability of RPE during the investigation (Table 2), a considerable number of the participants tended to demonstrate remarkable stability regarding perceptual strain (~67%). That is, there were no meaningful changes (i.e.  $\pm 1$  unit) in perception of effort when completing an identical exercise session following variable recovery periods. It would seem, at least within these individuals, that the theory of teleoanticipation was confirmed as there was no change in physiological and performance output either, which suggests that there was no overt threat to homeostasis experienced by these individuals. Thus, there was no need to adjust either rate of perceptual or metabolic strain or power output.

In instances in which the metabolic or physiologic state is altered from the baseline trial (i.e. variable recovery periods), the power output or rate of increase

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in perceptual strain in the subsequent trials would be negotiated if the disruption was great enough to pose a threat to successful completion or present a threat to homeostasis (St Clair Gibson et al. 2006; Hampson et al. 2001). This is executed within the teleoanticipatory brain centers either prior to or immediately following initiation of the exercise to ensure that gains in perceptual response remain identical between trials as long as the subject is aware of either the time or distance remaining at any point during the exercise (Crewe et al. 2008; Joseph et al. 2008; St Clair Gibson et al. 2006, 2003; Hampson et al. 2001). Yet, there was clearly a cohort of participants demonstrating an overall inconsistency in perceptual strain in the absence of significant changes in physiological, metabolic, or performance changes.

Results from this study do not tend to universally support the teleoanticipatory theory because RPEs demonstrated substantial intraindividual differences. However, no significant difference was found for the physiological markers collected (heart rate and blood lactate concentration) between trials, thus making any relationship between changes in physiologic strain to increases and decreases in RPE speculative at best. That notwithstanding, the 48-hour and 24-hour trials, on average, were the slowest and second slowest (lowest power outputs) of the four trials, respectively, and produced the highest RPE and S-RPE values as well as the highest blood lactate concentrations and heart rate responses. Conversely, the baseline and 72-hour trials produced the highest power outputs with lowest RPE and S-RPE values with concomitantly lower (although not significantly) physiological strain. When examined in conjunction with significantly higher S-RPE values following the 24-hour and 48-hour (*vs.* baseline trial and 72-hour trial), this may lend support that perceptual strain may mirror the changes in homeostatic disruption via feedback mechanisms as there was no change in power output (*i.e.* sprint times) found.

If individuals did not demonstrate any substantial differences in the rate of increase in RPE between bouts of exercise, independent of physiological strain, level of performance, or recovery status (Crewe et al. 2008; Joseph et al. 2008; Eston et al. 2007), then the theory of teleoanticipation would be confirmed. Recent studies have supported the notion of a scalar (*vs.* linear) increase in not only RPE, but with respect to metabolic and physiologic responses when examined relative to the percentage of time or distance completed rather than the absolute time spent exercising (Crewe et al. 2008; Joseph et al. 2008; Eston et al. 2007; Noakes et al. 2004). There has also been

support of time-based increases in RPE (Faulkner et al. 2008; Baden et al. 2004) without observed changes in pacing strategies or physiological strain reported in other work concerning RPE stability. This evidence seems to further support the notion of RPE increase having mediating factors that are not necessarily arising from the periphery but are consequences of internal timing.

The current study investigated multiple bouts of anaerobic sprint work in an ecologically valid setting (*i.e.* sprinting outdoors), with only recovery periods between trials altered; whereas studies confirming teleoanticipation employed aerobic-type, self-paced time trials or exercise performed to volitional exhaustion in which the participants were affected by manipulating their physiological status artificially (*i.e.* hypoxia, carbohydrate depletion, induction of fatigue, etc.). Thus, while maintaining a high degree of internal validity, some studies have limited ecological validity as the utility of the data derived from these types of settings (*i.e.* actual performance settings) can be more important than those observed during training sessions. In many sport situations (*i.e.* training), individuals do not perform self-paced time trials (other than races) or exercise to volitional exhaustion. Rather, they are assigned a workload and intensity by a coach/trainer. Recently, Faulkner et al. (2008) reported results supporting the teleoanticipatory theory during both a 7- and 13.1-mile competitive run performed in an ecologically valid setting. In their study, it was shown that RPE increased in a scalar fashion independent of changes in pacing and heart rate (Faulkner et al. 2008). While novel from an ecologically valid standpoint, direct comparison of results is difficult due to the different methodologies of the studies. To that end, there exist a number of disparities concerning the theory of teleoanticipation, seemingly due to the mode and intensity of exercise. If teleoanticipation is to be accepted as a universal mediator of not only perceptual response, but of global exercise performance, the associated theoretical concepts that diverge within the current study must be addressed. A primary concern would be the obvious variability in perceptual strain recorded during (RPE) and following (S-RPE) the trials in the absence of any loss in power output or rise in physiological strain in half of the study population.

It is important to acknowledge the possible presence of confounding variables that may have affected our results; however, all participants verbally acknowledged complying with the directions given to them prior to beginning the experiment (*i.e.* adequate rest, no exercise, replicated diet, etc.).

## Conclusion

In summary, the results from this study revealed considerable deviation for intraindividual perceived exertion during repeated intermittent type exercise performed after different recovery periods. The novel nature of this study was that it was performed in an ecologically valid, sport-specific setting consistent with day-to-day training regimens of team-sport athletes. There were clearly individuals that did report consistent and stable RPE values across all trials and all cycles during the experimental period in agreement with the theory of teleoanticipation. However, the frequency of inconsistent intraindividual RPE responses during identical exercise in half of the study population suggests there may be a diminished role of teleoanticipation during this particular mode and intensity of exercise. However, there was no evidence of RPE relating to physiological strain due to a lack of significant differences in the presence of increased global perceptual strain, although there were emerging trends in the data to suggest that a limited feedback (vs. feedforward) system was predominate. Due to the limited number of physiological variables measured (heart rate and blood lactate concentration), the notion of a predominant feedback mechanism should not be discounted as RPE is reportedly linked to other physiological factors such as oxygen consumption and ventilation that were not assessed. Consequently, more work regarding the factors that may more strongly influence perceptual response during this type of exercise is warranted.

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