AFFECTIVE RESPONSES TO A BOUT OF EXHAUSTIVE EXERCISE IN THE HEAT IN DEHYDRATED AND REHYDRATED STATES: IN SEARCH OF PHYSIOLOGICAL CORRELATES

P. EKKEKAKIS*, S.A. KAVOURAS**, D.J. CASA**, J.A. HERRERA**, L.E. ARMSTRONG**, C.M. MARESH**, S.J. PETRUZZELLO*

* Exercise Psychophysiology Laboratory, Department of Kinesiology, University of Illinois, Urbana, Illinois, USA

** Human Performance Laboratory and Department of Physiology and Neurobiology, University of Connecticut, Storrs, Connecticut, USA

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"Exercise psychologists have dismissed the complexity and purposes of autonomic and neuroendocrine regulatory responses to exercise, and exercise physiologists have been largely uninterested in studying mechanisms of 'central command'". (Dishman, 1990, p. 44).

Exhaustive acute exercise has traditionally been assumed to be emotionally aversive. This assumption has been empirically supported by in-task self-report assessments of affect during exercise of high intensity and/or prolonged duration. In response to such exercise, self-reports of affect typically exhibit a substantial degree of concordance with physiological indices. On the other hand, affective responses to highly demanding or maximal bouts of exercise, assessed as pre- to post-exercise changes, are characterized by substantial inter-individual variability (see Ekkekakis & Petruzzello, submitted, for a review). From a theoretical standpoint, these findings are considered indicative of a hypothesized dose-dependent interplay between cognitive coping and direct perception of physiological cues. The former is likely to be the dominant modulator of exertional and affective responses to exercise performed at submaximal levels, whereas the latter becomes dominant at maximal or near maximal levels. In a similar vein, research has shown that, while differences in temperature of drinking water were associated with different patterns of water intake during the early stages of a 6-hour intermittent exercise trial, physiological inputs (thirst, sweating, increased core temperature) possibly accounted for progressively converging drinking patterns during later stages (Armstrong, Hubbard, Szlyk, Matthew, & Sils, 1985).

The additional stressors of increased environmental temperature and dehydration, known to accentuate physiological responses to exercise, may also impact upon the psychological domain. In fact, exercising in the heat has been shown to be associated with reduced positivity of affect (Maw, Boutcher, & Taylor, 1993) and higher perceptions of effort, compared to similar exercise performed in cool or thermoneutral environments (see Acevedo & Ekkekakis, in press, for a review). In addition, studies that set forth to test the hypothesis that the anxiolytic effects of exercise are mediated by increases in body core temperature showed that such increases, in fact, lead to negative affective responses (e.g., Koltyn, Shake, & Morgan, 1993; Petruzzello, Landers, & Salazar, 1993). With respect to the effects of hydration state, research has shown that ratings of perceived exertion are typically increased by dehydration and restored by rehydration (e.g., Riebe, Maresh, Armstrong, Kenefick, Castellani, Echegaray, Clark, & Camaione, 1997). However, the effects of manipulations of hydration state on affective responses to exercise remain unresearched.

In this context, the purpose of this study was to examine the affective changes induced by a highly demanding protocol, involving bicycle ergometer exercise in the heat following dehydration, with or without rehydration. It was hypothesized that, because of the highly strenuous nature of the exercise stimulus under these conditions, affective responses would tend to be generally negative and that they could be accounted for to a certain extent by variables from the physiological domain. An additional purpose was to describe the phenomenological nature of affective changes induced under such conditions, using two dimensional self-report measures of affect.

METHODS

Subjects: Eight well-trained male cyclists (M_{age} = 23.3 ± 3.3 yrs; $M\dot{V}O_{2max}$ = 60.3 ± 3.9 ml·kg^{-1}·min^{-1}; M_{weight} = 69.8 ± 3.0 kg; $M_{Body\ Fat}$ = 13.9 ± 2.1%) participated in the study.

Measures: Affect was assessed by two dimensional self-report measures. The 16-item Circumplex Affect Inventory (CAI; Ekkekakis, 1996) includes 4 factors: activation (Act), valence (Val), activated pleasant-unactivated unpleasant affect (APUU), and activated unpleasant-unactivated pleasant affect (AUUP). The 20-item Activation-Deactivation Adjective Checklist (AD-ACL; Thayer, 1989) includes 2 factors: energetic arousal (EA) and tense arousal (TA). Physiological variables included heart rate (HR), systolic (SBP) and diastolic blood pressure (DBP) and mean arterial pressure (MAP), oxygen uptake (VO_2) and percentage of maximal oxygen uptake (%VO_2max), ventilation (V_E), respiratory rate (RR), respiratory exchange ratio (RER), skin (T_{sk}) and rectal (T_{re}) temperatures, and blood lactate (HLa).

Procedure: Subjects participated in 3 randomly ordered conditions: (a) exercise following rehydration with glycerol and water, (b) exercise following rehydration with placebo and water, and (c) exercise without prior rehydration (control condition). The day prior to each treatment, subjects underwent a 4% dehydration by water restriction and exercise. Upon arrival to the laboratory on each testing day, the subjects underwent 20 min of heat equilibration (36 °C), 20 min of cool equilibration (~22 °C), the rehydration treatment (90 min), and a second 20-min heat equilibration period, prior to commencing the exercise bout. Exercise was performed in the heat (36 °C) on a bicycle ergometer at 70% VO_2max to exhaustion (defined as volitional exhaustion, inability to maintain the determined pace, or a rise in T_{re} above 39.5 °C). Mean durations were 31.6 min in condition (a), 26.0 min in condition (b), and 18.4 min in condition (c). The affect measures were administered immediately prior to and immediately following the termination of the exercise bout. Physiological measures were collected throughout the exercise test, but for the present analysis only terminal or peak values were used.

RESULTS

An initial 3 (conditions: glycerol, placebo, control) by 2 (time: pre, post) within-subjects multivariate analysis of variance (MANOVA) showed that only the main effect of time was significant (Hotelling's T^2=112.68, p<.03, effect size=.991). Therefore, affective responses across conditions were averaged. Subsequent epsilon-adjusted repeated measures analyses of variance (ANOVAs) indicated significant changes for TA (F=8.23, p<.03) and APUU (F=6.81, p<.04). The subjects felt more tense (η^2=.540) and had more deactivated unpleasant (fatigued) affect (η^2=.493) as a result of exercise.

Physiological correlates of affective changes were sought via multiple regression analyses, using the affective pre-post-exercise change scores as dependent variables and physiological indices as predictors. A combination of HR and RR accounted for 92% of the variance in exercise-induced changes in TA in the control condition, and HR alone accounted for 66% of the variance in the placebo condition. No predictors were significant in the glycerol condition. Changes in APUU were accounted for by HR and SBP (R^2=.94) in the control condition, Body Fat in the glycerol condition (R^2=.74), and the increase in HR from baseline in the placebo condition (R^2=.86).

CONCLUSIONS

Exhaustive exercise in the heat following dehydration elicits negative affective changes, characterized by increased tension and an unpleasant low-activation state associated with fatigue. Bearing in mind the small sample size of this study, rehydration (or lack thereof) did not seem to affect the pattern of affective changes. Furthermore, in accordance with our theoretical expectation, a very substantial portion of the variance in affective change was accounted for by peak levels of physiological variables. From a conceptual standpoint, these findings are indicative of the strong role physiological cues play in modulating affective responses to exhaustive exercise.

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