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Research article

MOOD DISTURBANCE DURING CYCLING PERFORMANCE AT EXTREME CONDITIONS

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ABSTRACT
The purpose of the study was to investigate the effects of extreme environments on mood state changes in hypoxic conditions and cold conditions in comparison to baseline conditions. The research design involved participants completing a two-hour stationary cycle ergometer ride at a simulated altitude of 2,500 metres, O°C, and normal laboratory conditions at a pace equivalent of lactate threshold. Eight male elite cyclists (Age: M = 26.23 yrs., SD = 6.74) completed the hypoxia-normal cycling trials. Ten male highly trained cyclists (Age: M = 23.34 yrs., SD = 5.45) participated in the cold-normal trials. Mood was assessed before, after one hour, and after two hours using the 24-item Brunel Mood Scale. MANOVA results indicated no significant interaction effect for mood changes over time by environment condition (Wilks' Lambda = .73, p = .32, Eta^2 = .05), a significant main effect for mood changes over time (Wilks' Lambda = .61. p < .001, Partial Eta^2 = .15) and a significant main effect for differences in mood by condition (Wilks' Lambda = .72, p < .000, Partial Eta^2 = .15). Results indicated that increased anger, depression and fatigue were associated with performing at altitude, particularly after two hours of exercise. Collectively, results lend support to the notion that altitude is associated with negative mood states, although it should be noted that environment conditions did not affect the change in mood states over time. We suggest that further research is needed to explore mechanisms that individuals use to regulate negative mood during strenuous exercise.

KEY WORDS: Mood, coping, environment, altitude, cold, performance.

INTRODUCTION

Elite athletes may sometimes have to produce optimal performance in extreme environmental conditions. It is well documented that strenuous exercise in extreme environments such as altitude, heat and cold imposes increased physiological and psychological stress (Bolmont et al., 2000; 2001). A great deal of research on the effects of extreme environments is conducted using mountaineers or other groups who regularly perform under such conditions, rather than among athletes who tend to perform and train under normal conditions and occasionally perform in extremes. Lane et al. (2004) emphasised the importance of monitoring mood states responses to extreme environmental conditions among elite athletes. Mood is proposed to reflect training volume and predict performance. Theoretically, it is argued that mood has a signal or informative function, whereby it is suggested that individuals consult their feelings on whether they have the personal resources to perform the necessary action successfully, and thus mood is reflexive of environmental changes (see Lane et al., 2004). In the present study, we investigated mood changes among athletes performing strenuous exercise in two different extreme environments in simulated laboratory conditions; 1) hypoxic conditions, and 2) cold conditions in comparison to performing at the same intensity under normal conditions.

Studies into the effects of altitude on mood tend to show that negative mood increases with hypoxia (Elmore and Evans, 1983; Banderet and Burse, 1991; Bahrke and Shukitt-Hale, 1993; Bonnon et al., 1999; Piehl- Aulin et al., 1998; Bolmont et al., 2000; 2001). Shukitt-Hale et al. (1991) found that negative mood states were associated with poor cognitive performance among a sample of 20 male soldiers performing at altitudes of 4,200 metres and 4,700 metres. Similarly, Crowley et al. (1992) reported that negative mood was associated with poor cognitive performance among a sample of 13 male soldiers performing at 4300 metres. It should be noted that studies tend to use mountaineers as participants at high altitude, and certainly, a great deal higher than most athletes perform in competition. Other studies conducted show no negative affects of hypoxic conditions (Bonnon et al., 1999; Piehl et al., 1998; Whyte et al., 2002; Lane et al., 2003).

A review paper on the effects of hot and cold conditions on psychological responses by Kobrick and Johnson (1991) reported that findings between studies vary considerably. Kobrick and Johnson (1991) highlighted that methodological differences between studies served to complicate the literature. However, it has been argued that the evidence for the influence of cold conditions on mood is strong enough for researchers to use cold conditions as a means of inducing negative mood in experimental studies (Willoughby et al., 2002). By contrast, Acevedo and Ekkekakis (2001) argued that performing intense exercise in the cold might facilitate performance among highly motivated athletes, although this benefit might be a function of the cold serving as a heat reduction strategy.

Given contrasting evidence, it is unclear whether athletes consistently experience negative mood when performing in extreme conditions. Identifying the impact of performing strenuous exercise in extreme conditions on mood state responses might aid in the development of intervention strategies to improve mood. The purpose of the study was to investigate changes in mood states during strenuous exercise in normobaric hypoxic conditions, cold conditions, and during normal conditions.

METHODS

Participants

Eight male elite cyclists (Age: M = 26.23 yrs., SD = 6.74) completed the hypoxia-normal cycling trials. Participants reported to train for a rounded average of 14.45 hours per week (SD = 1.54). Ten male highly trained cyclists (Age: M = 23.34, SD = 5.45 years, range 18-35 years) participated in the cold-normal trials. Participants trained for a rounded average of 14 hours per week (SD = .23 hours). All participants had competed internationally and reported to cycle regularly in the UK outside during the year, and therefore experience training in cold conditions in the winter months. All athletes reported to have had some experience of training at altitude, but none had been at altitude in the previous year.

Measures

Mood was assessed using the Brunel Mood Scale (BRUMS: Terry et al., 1999; 2003). The BRUMS assesses anger, confusion, depression, fatigue, tension, and vigor, hence is a derivative of the Profile of Mood States (McNair et al., 1971; 1992). Anger items include “Bad-tempered” and “Angry”, Confusion items include “Muddled” and “Uncertain”, Depression items include “Depressed” and “Miserable”, Fatigue items include “Sleepy” and “Tired”, Tension items include “Anxious” and “Panicky”, and Vigor items include “Lively” and “Energetic”. Items are rated on a 5-point scale anchored by “not at all” (0) and “extremely” (4). Validation of the BRUMS involved 3,361 participants ranging in age from 12-39 years (Terry et al., 1999; 2003). Confirmatory factor analysis supported the factorial validity of a 24-item six-factor model using both independent and multisample analyses among athletic samples. Lane and Terry (1998) found the BRUMS scores predicted time trial cycling performance.

Cycling performance test

Participants performed two-hour (approximately 50-mile) cycle bouts on a stationary cycle ergometer rig (Kingcycle, High Wycombe, UK) at an equivalent power output to lactate threshold (previously determined in normal laboratory conditions at 19°C). The normal condition involved cycling in a laboratory at 19°C. The hypoxic trial was completed in a commercially available hypoxic chamber (Edge 4, London, UK). The chamber reduces the F_IO_2 via a ventilation system that simultaneously draws both ambient air (≈ 20.93% O_2 and ≈79.0% N_2) and a gas comprised of 100% N_2 into the chamber. This leads to an intra-chamber gas composition of ≈15.3% O_2 and ≈84.7% N_2, approximately equivalent to an altitude of 2500m. The 0°C trial was completed in a commercially available climatic chamber (SANYO, Gallenkamp PLC, Loughborough, U.K).

Procedure

The institution of the first author granted ethical approval. Participants gave informed written consent before testing. The BRUMS was completed immediately before cycling, after the first hour, and again after the second hour before stopping. Participants completed the BRUMS using the “How do you feel right now?” instructional set. Participants performed the test individually with only the experimenters in the laboratory hence, the potentially motivating effects of other riders was controlled. Participants were freely allowed to drink water during all trials. Both cycle trials were separated by two weeks.

Data were analyzed by comparing mood state changes over time (pre, 1 hour, 2 hours, and post) by environment condition (cold vs hypoxia vs normal) using multivariate analysis of variance. A preliminary data analysis check was made on mood changes between the two normal conditions.

RESULTS

Initial physiological testing indicated that participants were well-trained athletes with an average VO_{2max} score of 65.6 (*SD* = 7 $ml \cdot kg^{-1} \cdot min^{-1}$). The wattage associated with lactate threshold (M = 226.7, SD = 28.3 watts) indicated that participants could sustain a relatively high level of workload from aerobic sources.

MANOVA results indicated no significant interaction effect for mood changes over time by environment condition (Table 1, Wilks' Lambda = .72, $p = 0.14$, $Eta^2 = 0.08$, a significant main effect for mood changes over time (Wilks' Lambda = 0.57, $p < 0.001$, $Eta^2 = 0.25$) and a significant main effect for differences in mood by condition (Wilks' Lambda = 0.65, $p < 0.001$, $Eta^2 = 0.19$). Although the multivariate effect was not significant, univariate interaction effects were found for anger ($F = 3.70$, $p < 0.01$, $Eta^2 = .13$) and fatigue ($F = 2.75$, $p < 0.05$, $Eta^2 = 0.10$) where anger and fatigue increased significantly more during exercise at altitude after the first hour.

Univariate results were evident for mood changes over time for anger ($F = 4.15$, $p < 0.05$, $Eta^2 = 0.08$) and fatigue over time ($F = 16.63$, $p < 0.001$, $Eta^2 = 0.26$) with significant increases in fatigue following the second hour of exercise. Univariate results for the effects of environment on mood indicated anger ($F = 13.41$, $p < 0.001$, $Eta^2 = 22$), confusion ($F = 6.04$, $p < 0.01$, $Eta^2 = 0.11$) depression ($F = 7.53$, $p < 0.01$, $Eta^2 = .14$), fatigue ($F = 11.84$, $p < 0.001$, $Eta^2 = .20$) and tension ($F = 6.95$, $p < 0.01$, $Eta^2 = 0.13$) scores were significantly higher at altitude than either cold or normal conditions.

DISCUSION

The present study examined changes in mood states during a two-hour cycle performance in adverse environmental conditions. Results demonstrated that performing intense exercise was associated with increased fatigue regardless of environment conditions. Results for changes in anger over time indicated that it increased significantly after an hour of exercise when performing at altitude, with no significant differences in anger in cold and normal conditions.

Table 1. Mood scores over time by environment condition. Data are means (±SD).

Mood	Time	Normal	Altitude	Cold
Anger	Pre test	45.23 (2.18)	44.87 (1.16)	44.79 (1.04)
	1 hour	44.46 (.00)	51.02 (8.76)	44.46 (.00)
	2 hours	45.62 (2.58)	51.43 (7.32)	45.12 (1.38)
Confusion	Pre test	42.05 (1.58)	42.88 (1.39)	44.27 (5.28)
	1 hour	41.66 (.00)	47.36 (9.66)	42.64 (1.57)
	2 hours	41.85 (.79)	44.51 (5.35)	42.64 (2.20)
Depression	Pre test	44.27 (2.56)	44.32 (2.41)	43.47 (.00)
	1 hour	43.77 (1.13)	51.12 (13.45)	43.81 (1.08)
	2 hours	44.27 (2.26)	50.27 (10.28)	44.83 (3.29)
Fatigue	Pre test	40.40 (2.70)	41.42 (4.86)	42.05 (3.47)
	1 hour	41.47 (3.60)	49.68 (9.57)	42.28 (3.56)
	2 hours	45.90 (5.92)	55.95 (9.89)	45.70 (5.61)
Tension	Pre test	44.63 (5.00)	49.39 (11.63)	50.92 (9.46)
	1 hour	42.15 (1.87)	52.27 (14.50)	43.23 (2.69)
	2 hours	42.60 (1.68)	46.98 (11.06)	44.39 (4.07)
	Post-test	42.82 (3.27)	41.69 (.00)	42.46 (1.62)
Vigour	Pre test	51.31 (11.07)	56.84 (9.77)	54.11 (8.35)
	1 hour	51.47 (11.61)	50.37 (10.65)	50.57 (8.40)
	2 hours	51.79 (11.56)	48.67 (6.99)	44.85 (7.96)

Results also showed that an equivalent altitude of 2500m was associated with increased anger, confusion, depression, fatigue, and tension. Findings of the present study lend some support for previous research that shows increased negative mood with hypoxia (Elmore and Evans, 1983; Banderet and Burse, 1991; Bahrke and Shukitt-Hale, 1993; Bonnon et al., 1999; Piehl-Aulin et al., 1998; Bolmont et al., 2000). Lane et al. (2004) argued that stress-responses to extreme environments become exacerbated among athletes used to performing at sea level who are required to perform at extreme conditions on an irregular basis. Lane et al. (2003) used this argument in their work with biathletes in preparation for the 2002 Winter Olympic Games. Findings of the present study lend support to the benefits of acclimatising to altitude for reducing the likelihood of athletes experiencing negative mood during intense exercise.

Results indicated that there was no significant difference in mood states between performing in the cold and normal conditions. Although previous research has found evidence to suggest that negative mood states are associated with performing strenuous exercise in cold environments (Kobrick and Johnson, 1991), this has not been consistently reported. Indeed, Acevedo and Ekkekakis (2001) argued that performing intense exercise in the cold might be beneficial to some athletes as it serves as a heat reduction strategy. It should be noted that athletes in the present study where able to drink water ad libatum, and therefore this might have lead to discrepancies in sweat production and heat dissipation. It is possible that ad-lib drinking in the present study could counter-balance the proposed motivational effects of performing in the cold. Future research should control fluid ingestion across trials.

It is possible that non-significant effects for cold and significant effects for altitude could be explained by the previous experiences of athletes within the samples. Participants were experienced cyclists who trained regularly in the UK. Typical changes in the weather in the UK would mean that if participants ride on a regular basis, they should be familiar with riding in cold conditions similar to those used in the present study. Recent research indicates that teaching athletes how to cope with altitude by training in an altitude chamber whilst living under normal conditions is associated with enhanced mood states in hypoxic conditions (Lane et al., 2003; Whyte et al., 2002). It is suggested that athletes can learn strategies to regulate mood states associated with altitude, something that athletes in the present study were less likely to have done. It is suggested that similar mood responses could have occurred if athletes were equally familiar with performing at altitude as they were in the cold.

Acevedo and Ekkekakis (2001) argued that research should investigate affective changes in response to exercise in extreme conditions using a transactional design in which the mood states responses at one point in time are important sources of information in how athletes cope with situational and environmental stressors. Studies that test transactional research designs are rare due the complexity and difficulty of taking multiple measures at different time points during performance. However, mood researchers have emphasized the transitory nature of mood states, and the importance of investigating how mood states interact (Lane and Terry, 2000). The present study showed that anger and fatigue increased over time. Findings for fatigue should be not be surprising given athletes reported low scores at the start of the investigation, and it is reasonable to expect fatigue to increase in response to strenuous exercise. It is suggested that athletes used anger as a strategy to raise energy levels when performing at altitude. Lane and Terry (2000) argued that some individuals could learn to regulate anger to optimum levels, and use anger to enhance determination.

We suggest that there is need for future research to investigate mood state changes to strenuous exercise. We argue that future research is needed to address the acknowledged limitations within the present study. Acevedo and Ekkekakis (2001) suggested investigated affective changes using psycho-physiological model. Although research has tested each part of the model separately, research has not tested the entire model simultaneously. It is suggested that future research tests the psycho-physiological model proposed by Acevedo and Ekkekakis (2001). A second line of future research could test the effectiveness of mood-regulating strategies on mood state responses to exercise in extreme conditions. There is a need for well-controlled studies to explore this proposal, however, we suggest that future research utilizes an ecologically valid design. A limitation of the present study is that athletes performed in laboratory conditions, and although this allows for the control of potentially confounding variables such as changes in environment conditions during an event, the mindset linked with a laboratory trial is likely to differ than before an important competition.

Collectively, it is suggested that future research attempts to explore the mechanisms through which athletes learn to cope with performing in extreme conditions.

CONCLUSION

In conclusion, findings of the present study support the notion that performing strenuous exercise in adverse conditions is associated with increased negative mood. We suggest that further research is needed to explore mechanisms that individuals use to regulate negative mood during strenuous exercise.

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KEY POINTS

- The present study found that mood state changes were more pronounced when performing at a simulated altitude of 2,500 metres than performing in the cold and normal laboratory conditions at a pace equivalent of lactate threshold.
- Findings from the present study indicate that that altitude is associated with negative mood states,
- Results show that mood states change during extreme exercise with increases most notably in fatigue and reductions in vigor. It should be noted that environment conditions did not affect the change in mood states over time.
- We suggest that further research is needed to explore mechanisms that individuals use to regulate negative mood during strenuous exercise.

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