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Research article

Regular exercise participation mediates the affective response to acute bouts of vigorous exercise

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Abstract

Physical inactivity is a leading factor associated with cardiovascular disease and a major contributor to the global burden of disease in developed countries. Subjective mood states associated with acute exercise are likely to influence future exercise adherence and warrant further investigation. The present study examined the effects of a single bout of vigorous exercise on mood and anxiety between individuals with substantially different exercise participation histories. Mood and anxiety were assessed one day before an exercise test (baseline), 5 minutes before (pre-test) and again 10 and 25 minutes post-exercise. Participants were 31 university students (16 males, 15 females; Age $M = 20$), with 16 participants reporting a history of regular exercise with the remaining 15 reporting to not exercise regularly. Each participant completed an incremental exercise test on a Monark cycle ergometer to volitional exhaustion. Regular exercisers reported significant post-exercise improvements in mood and reductions in state anxiety. By contrast, non-regular exercisers reported an initial decline in post-exercise mood and increased anxiety, followed by an improvement in mood and reduction in anxiety back to pre-exercise levels. Our findings suggest that previous exercise participation mediates affective responses to acute bouts of vigorous exercise. We suggest that to maximise positive mood changes following exercise, practitioners should carefully consider the individual's exercise participation history before prescribing new regimes.

Key words: Exercise, mood, affect, anxiety, exercise adherence.

Introduction

On a population level, regular physical exercise is associated with significant cardiovascular and mental health benefits (Biddle, 2000; Deslandes et al., 2009; Joyner and Green, 2009). Maximizing these positive health effects is an important public health objective. While many factors can influence exercise adherence rates (the cost, convenience, social support, perceived risks and benefits), recent research has shown that the affective response to acute bouts of physical activity can predict future exercise participation (Ekkekakis et al., 2008; Williams et al., 2008). If exercise is to become a regular part of one's lifestyle, rather than something that is done in spurts of activity followed by long periods of inactivity, novice exercisers

may need to anticipate not only long term health benefits, but also experience immediate psychological rewards, such as improved mood states.

Participation in short-term exercise tends to be associated with improvements in transitory mood states, but not necessarily for all individuals (Bartholomew et al., 2005; Kwan and Bryan, 2010; Petruzzello et al., 1991). The affective benefits of acute exercise may be reduced, eliminated, or even reversed by exercising too intensely or for too long. Research indicates that several factors relating to both the exercise itself (in particular, the intensity and duration of exercise) and the individual participant (previous exercise involvement, perceptions of outcome and cognitions during exercise), interact to bring about post-exercise changes in mood (Bixby and Lochbaum, 2006; Dunn et al., 2005). However, it is unclear at present how these factors interact to modify affective responses. To date, several investigations have explored the relationship between previous exercise participation and mood change following acute bouts of exercise (Boutcher et al., 1997; Lochbaum et al., 2004; Parfitt et al., 1994; Steptoe et al., 1993; Tieman et al., 2002). This research has produced inconsistent findings, with some studies indicating that exercise can positively influence mood states irrespective of participant activity status (Daley and Welch, 2003), while other studies suggest that previous exercise experience is an important mediator of exercise induced mood change (Hoffman and Hoffman, 2008). For example, Steptoe et al (1993) examined the effect of three exercise intensities (volitional exhaustion, 70% of $\dot{V}O_2$ max and 30% of $\dot{V}O_2$ max) in active and inactive men. Sportsmen, but not inactive men, showed a decrease in tension-anxiety following the maximal exercise test, while exhilaration increased in both groups. Increases in mental vigor and exhilaration were recorded two minutes after exercise at 70% and 50% of $\dot{V}O_2$ max, and these responses were significantly greater than those in the control condition. In a similar investigation, Daley and Welch (2003) explored the relationship between subjective mood experiences and exercise intensity in active and inactive females. All participants reported significantly higher Psychological Well-Being scores but only in the low intensity exercise condition (Daley and Welch, 2003). Recently, Hoffman and Hoffman (2008) compared the effect of a moderate treadmill exercise for 20 minutes on mood in middle-aged exercisers and non-exercisers. Hoffman and Hoffman found that a single session of moderate aerobic exercise improved vigour and decreased

fatigue among regular exercisers but caused no change in these scores for non-exercisers. One important variable which may partly account for these inconsistent results is the exercise intensity, which has been shown to influence the mood response following acute exercise (Dishman et al, 1994; Dunn et al, 2005; Ekkekakis et al, 2008; Williams, 2008).

Moderate exercise testing protocols have considerable external validity because they mimic the exercise intensity level that many individuals naturally self-select in 'real life' exercise settings. However, further investigations of the relationship between acute bouts of *intense* exercise and mood among individuals with different exercise participation histories are important for at least two reasons. Firstly, the effects of intense exercise on mood and anxiety are less frequently reported in the literature compared to moderate or sub-maximal exercise. Where the effects are reported, the results have not been consistent, suggesting that further investigations are warranted (Daley and Welch, 2003; Dishman et al., 1994; Lind et al., 2008; Tieman et al., 2002). Secondly, recent evidence suggests that novice exercisers may be less skilled at self-regulating their own exercise intensity levels – in other words, they frequently have difficulty 'pacing themselves' through the early stages of a new exercise program (Williams, 2008). In addition, the exercise prescribed by a gym instructor, personal trainer or exercising friend, may be too intense for the novice exerciser's current level of fitness. Poor self-regulation of the exercise intensity could lead non-regular exercisers to over-exert themselves during the early stages of an exercise program, resulting in negative mood states and poor long term adherence. Therefore, in light of research indicating that both exercise intensity and previous exercise participation are important mediating factors in the exercise-affect link, the present study set out to investigate the effects of a single bout of intense exercise on mood and anxiety in a cohort of male and female regular and non-regular exercisers. We hypothesized that regular exercisers would report post-exercise improvements in mood states and reduced anxiety, while non-regular exercisers would report an initial decline in mood and increased post-exercise state anxiety.

Methods

Participants

Thirty-one participants ($M = 20.13$ years, $SD = 2.96$ years) were recruited voluntarily from a university sports science and social science program, and classified as either regular or non-regular exercisers based on their responses to an exercise participation questionnaire. All participants were enrolled as undergraduate students at the time of the study and were free of known cardiovascular and respiratory diseases. Exclusion criteria included known pregnancy, the use of tobacco products, mood-altering medications or drugs, and musculoskeletal disorders interfering with exercise.

A small financial incentive of \$20 was offered to all participants who agreed to volunteer for the study.

Participants recruited from the sport science class were already required to exercise regularly as part of their education; therefore, thirteen of the sixteen regular exercisers (eight male, eight female) were recruited from an undergraduate sports science program. Only two of the social science students met the criteria for 'regular exerciser' in this study. Of the 31 participants, seven males and eight females were classified as non-regular exercisers. Recruitment into the study continued until an approximately even number of males and females had volunteered to participate. Three participants were rejected from the study for failing to clearly meet the classification of either regular or non-regular exerciser.

Materials

The experiment was conducted in an Exercise Physiology Laboratory with incremental exercise carried out on a Monark cycle ergometer (Monark Exercise AB, Vansbro, Sweden). Four identical questionnaires were completed by each participant at baseline, pre-test, 10 minutes post-test, and 25 minutes post-test. Each questionnaire contained the following four inventories;

(1) The Exercise-Induced Feeling Inventory (EFI) (Gauvin and Rejeski, 1993) was included specifically to measure fluctuations in mood state after acute exercise. The EFI consists of four subscales derived from 12 separate items, and takes about one minute to complete. All items are scored on a 5-point scale anchored from 0 (do not feel) to 4 (feel very strongly). For each item, respondents must indicate how they feel 'right now, at this moment'. The four subscales are: (1) Positive Engagement (Enthusiastic, Happy, Upbeat); (2) Revitalisation (Refreshed, Energetic, Revived); (3) Tranquillity (Calm, Relaxed, Peaceful); and (4) Physical Exhaustion (Fatigued, Tired, Worn Out). Subscale scores are obtained by averaging the numerical values chosen for the adjectives within a particular subscale. For example, the score for the Positive Engagement subscale is the sum of scores from 'enthusiastic', 'happy', 'and 'upbeat'. Subscale scores range from 0 to 12. The reliability and validity of the EFI is reported to be adequate (Gauvin and Rejeski, 1993). Higher scores on the EFI total and subscales indicate more positive mood states, except on the Physical Exhaustion subscale where high scores indicate *greater* physical exhaustion.

(2) The 65-item Profile of Mood States questionnaire (POMS) (McNair et al., 1971). The POMS is a self-report inventory, requiring only a few minutes to complete, that has been used extensively to assess the acute effects of exercise on mood (Biddle, 2000; Hoffman and Hoffman, 2008; Petruzzello et al, 1991). The POMS measures 6 dimensions of mood on a 5-point continuum. A total mood disturbance index is derived by subtracting the vigor-activity score from the sum of the other 5 measures of affect (tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia, confusion-bewilderment). High scores on the POMS total and subscale scores indicate more *negative* mood states, except on the Vigor-Activity subscale where higher scores stronger feelings of Vigor.

(3) Both the state and trait subscales of the State-Trait Anxiety Inventory (STAI) (Spielberger et al., 1970) were included. On the trait anxiety scale, participants responded according to how the items described them "in general", whereas on the state anxiety inventory participants indicated the extent to which items described them "at that particular moment". The STAI provides an operational measure of anxiety at a particular moment (State) and of stable anxiety (Trait). The two STAI scales each comprise 20 items rated on a 4-point scale. High scores on the STAI indicate higher levels of self-reported anxiety, while low scores suggest lower anxiety levels.

Both the EFI and POMS were selected for the present study to allow comparisons between the two inventories within the same study. A separate measure of anxiety (the STAI) was adopted to explore changes in state anxiety over time, and differences between regular and non-regular exercisers in trait anxiety at baseline. This would not have been possible using the POMS questionnaire alone.

Procedure

All participants completed the first (baseline) questionnaire 24 hours prior to their exercise session, and again immediately before the exercise test. The timing of the questionnaires enabled an assessment of whether the participant's anxiety rose immediately prior to the exercise intervention compared to baseline. The baseline questionnaire contained instructions that participants were asked to comply with prior to the exercise test (for example, do not drink coffee, alcohol or other non-prescription drugs 24 hours before the test). Revealing our study hypotheses to the participants might have influenced the results by generating preconceptions about the positive effects of exercise on mood. Therefore, the true focus of the experiment was concealed until the conclusion of the study when all participants were debriefed by mail. All participants were informed that the study was investigating gender differences in exercise performance, and its influence on cognition.

Upon entering the exercise laboratory, each participant was familiarised with the equipment and given clear but brief instructions regarding the protocol to be followed. The laboratory was a medium sized (approximately 45 square meter), well lit exercise testing room containing one stationary exercise cycle, a treadmill with VO_2 max testing equipment, a small table and a chair. A window was left open at all times to ensure adequate ventilation. The instructor was mindful to engage each participant in a similar manner, and avoided unnecessary social interaction with the participants. Each volunteer was weighed on an electronic scale and their age, height and weight recorded (see Table 1). Participants then com-

pleted a health questionnaire, an exercise participation questionnaire and a written consent form. Before performing the exercise test, each participant was fitted with a Polar heart rate monitor and the bicycle ergometer seat height was adjusted to suit the participant's comfort. The second pre-test questionnaire was then completed, after which the exercise testing session was conducted. Participants were provided drinking water before the test began. The Monark cycle ergometer used in the present study was similar to a stationary exercise bicycle. The intensity of the exercise was increased by adjusting the resistance force applied to the flywheel of the ergometer, which could be gauged by the position of a pendulum.

Testing procedures followed the American College of Sports Medicine's (1986) cycle ergometer maximal test protocol. Each participant was instructed to begin pedaling in time to a metronome that set a pedaling rate of 50 revolutions per minute (rpm). The initial workload was set at 300 kilogram meters per minute ($\text{kgm}\cdot\text{min}^{-1}$) for females, and 600 $\text{kgm}\cdot\text{min}^{-1}$ for males. The workload was increased by 150 $\text{kgm}\cdot\text{min}^{-1}$ every two minutes (for both males and females) until volitional exhaustion. The cycle ergometer was re-calibrated between each testing session to ensure accurate and reliable measures. During the exercise test, participants were verbally encouraged to cycle to the point of volitional exhaustion. The testing procedure ensured that the final relative exercise intensity experienced by each participant was similar, despite differences in fitness and final exercise workload. Following a 5 minute cool-down period of slow pedaling with minimal resistance, participants completed the first post-exercise questionnaire by sitting quietly in a chair at a writing table. The second post-exercise questionnaire was completed 25 minutes after the exercise session. Participants sat quietly and rested between completion of the first and second post-exercise questionnaire and were provided drinking water and a sweat towel.

Upon completion of the final EFI questionnaire at 25 minutes, participants maximum oxygen uptake was estimated from the oxygen uptake equivalent to the final workload (taken from a modified Astrand-Rhyming nomogram) and expressed relative to body weight in $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. This procedure was replicated for all 31 individuals.

Results

Two measures were used to estimate fitness levels among participants; VO_2 max and cycling time to exhaustion. Independent samples t-tests revealed regular exercisers had higher VO_2 max (mean = 56.75 $\text{ml}\cdot\text{min}^{-1}$) than non-regular exercisers (mean = 39.40 $\text{ml}\cdot\text{min}^{-1}$). Regular exercisers also cycled for a longer duration (12.56 min.) than

Table 1. Participant characteristics.

	Regular exercisers		Non-Regular Exercisers	
	M (n =8)	F (n = 8)	M (n =7)	F (n = 8)
Age (years)	22.8 (4.5)	19.7 (1.8)	18.7 (.4)	19.0 (.9)
Height (m)	1.79 (.05)	1.66 (.06)	1.82 (.06)	1.58 (.07)
Weight (kg)	80.2 (7.1)	59.8 (5.7)	76.4 (6.4)	57.4 (6.2)

Table 2. Mean and (standard error) total and subscale scores for the EFI, POMS and STAI over time.

Measure category	Exercise	Baseline	Pre-test	10 min Post	25 min Post	P group x time interaction	Effect size (Eta ²)
EFI total	Regular	13.7 (2.1)	18.7 (2.3)	22.0 (2.1)	26.5 (1.8)	< .001	.560
	Non-Regular	13.7 (2.2)	17.7 (2.3)	4.5 (2.2)	15.3 (1.9)		
Positive engagement	Regular	5.8 (0.6)	7.3 (0.6)	8.1 (0.6)	8.9 (0.6)	< .001	.537
	Non-Regular	7.2 (0.6)	8.3 (0.6)	4.8 (0.6)	7.0 (0.6)		
Revitalisation	Regular	5.2 (0.6)	6.0 (0.6)	7.2 (0.7)	8.6 (0.6)	< .01	.314
	Non-Regular	5.7 (0.7)	6.0 (0.6)	3.2 (0.7)	6.6 (0.7)		
Physical exhaustion	Regular	5.2 (0.8)	3.2 (0.8)	2.6 (0.7)	0.7 (0.5)	< .001	.537
	Non-Regular	4.5 (0.8)	3.5 (0.8)	7.3 (0.7)	4.9 (0.5)		
Tranquility	Regular	7.9 (0.7)	8.6 (0.6)	8.3 (0.7)	9.5 (0.5)	< .26	
	Non-Regular	5.2 (0.7)	6.8 (0.6)	4.1 (0.8)	6.7 (0.6)		
POMS total	Regular	19.6 (8.2)	11.8 (6.7)	-2.8 (7.6)	-7.9 (6.3)	< .002	.438
	Non-Regular	52.5 (8.4)	28.3 (6.9)	40.0 (7.9)	31.1 (6.5)		
tension	Regular	8.7 (1.7)	5.8 (1.4)	3.9 (1.0)	3.5 (1.3)	< .64	
	Non-Regular	16.0 (1.8)	12.7 (1.5)	13.0 (1.0)	11.5 (1.4)		
depression	Regular	6.3 (1.9)	3.7 (1.9)	2.0 (2.2)	3.5 (1.3)	< .19	
	Non-Regular	14.5 (2.0)	9.7 (1.9)	11.9 (2.3)	11.5 (1.4)		
anger	Regular	7.0 (2.0)	5.2 (1.7)	3.3 (1.7)	2.1 (1.3)	< .44	
	Non-Regular	15.5 (2.1)	10.8 (1.7)	8.0 (1.8)	7.1 (1.3)		
confusion	Regular	7.7 (1.2)	5.3 (1.2)	4.4 (1.4)	2.9 (1.2)	< .08	
	Non-Regular	11.1 (1.2)	7.9 (1.2)	8.8 (1.4)	9.2 (1.3)		
vigor	Regular	17.7 (1.5)	19.1 (1.5)	19.6 (1.7)	21.0 (1.5)	< .01	.328
	Non-Regular	17.3 (1.5)	20.8 (1.5)	14.6 (1.8)	17.1 (1.6)		
fatigue	Regular	8.1 (1.6)	6.5 (1.0)	4.1 (1.4)	3.4 (1.1)	< .001	.490
	Non-Regular	12.9 (1.7)	7.9 (1.0)	14.0 (1.4)	10.7 (1.1)		
State Anxiety (STAI)	Regular	38.6 (3.6)	30.6 (2.1)	27.8 (2.7)	28.7 (2.4)	< .005	.387
	Non-Regular	41.6 (3.7)	36.6 (2.2)	45.8 (2.8)	37.9 (2.5)		
Trait Anxiety (STAI)	Regular	34.2 (2.2)	31.8 (2.1)	31.2 (2.0)	30.2 (1.7)	< .27	
	Non-Regular	41.4 (2.3)	41.1 (2.1)	40.9 (2.1)	37.4 (1.8)		

*Effect sizes (Eta²) for statistically significant group by time interaction effects using repeated measures ANCOVA.

non-regular exercisers (10.33 min.), confirming their superior fitness levels. Both V_O₂ max and time to exhaustion measures were found to differ significantly between regular and non-regular exercisers ($t(29) = 3.45$, $p < 0.05$ and $t(29) = 2.84$, $p < 0.05$ respectively), indicating that regular exercisers were fitter than the non-regular exercisers.

Interaction effects (group by time), and main effects of group only were explored using repeated measures ANCOVA. Mean and standard error scores from each questionnaire are presented in Table 2, below.

The exercise-induced feeling inventory

Changes over time on the EFI total scores (Figure 1) and subscale scores (Figure 2) for regular and non-regular exercisers are illustrated below. Higher scores on the EFI total indicate more positive mood states, while low scores indicate negative mood states. On the Physical Exhaustion subscale, higher scores indicate negative mood states. The results indicated a significant interaction between exercise group (regular versus non-regular) and time after controlling for age as a covariate, $F_{1,26} = 11.01$, $p < 0.001$ (Eta² = 0.560). Regular exercisers reported a steady improvement in mood scores across time from baseline through to 25-minutes post-exercise. Conversely, non-regular exercisers reported an initial increase from baseline to pre-test, followed by a sharp decrease in mood scores at 10-minutes post-exercise, and then a return to pre-exercise mood levels at 25-minutes. Post-hoc analyses using

EFI total scores indicated that regular exercisers reported significantly better mood states than non-regular exercisers at both 10 minutes ($p < 0.01$, Cohen's $d = 2.07$) and 25 minutes after exercise ($p < 0.05$, Cohen's $d = 1.58$).

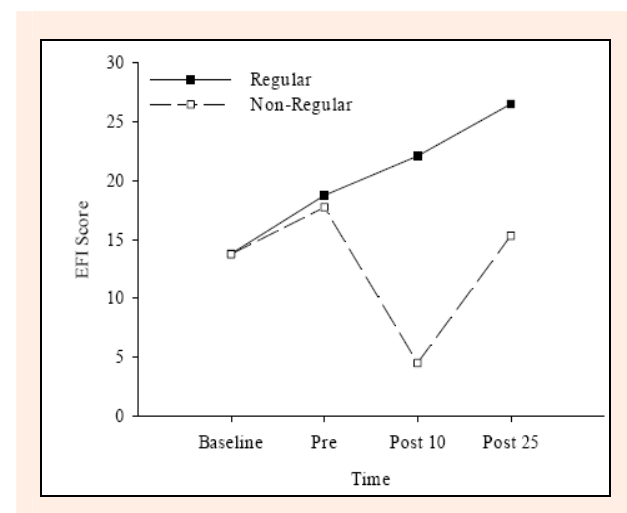


Figure 1. Total EFI scores for regular and non-regular exercisers across time.

Changes over time on the EFI subscales followed a similar pattern to the EFI total scores, with the positive engagement, revitalization, and physical exhaustion subscales all showing a significant group by time interaction. The tranquility subscale was the only exception to this

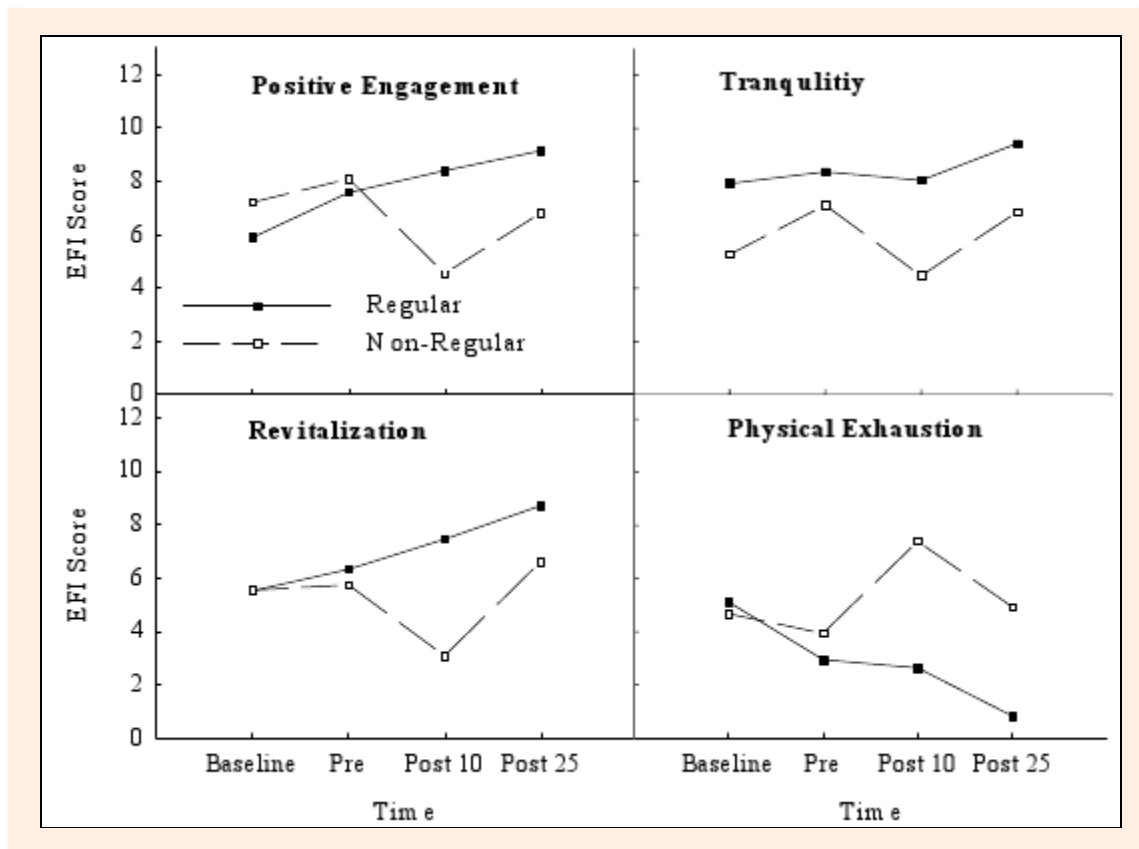


Figure 2. EFI subscale scores for regular and non-regular exercisers across time.

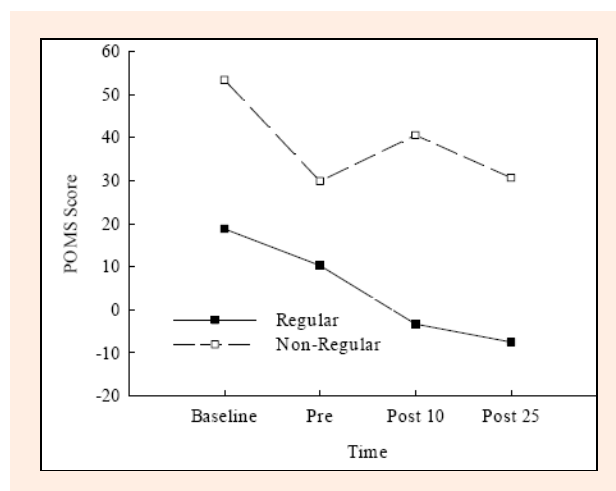


Figure 3. POMS total scores for regular and non-regular exercisers across time.

trend, where no significant interaction was obtained.

Profile of mood states

Figure 3 shows changes over time in POMS total scores between regular and non-regular exercisers. High scores on the POMS indicate more *negative* mood states, whereas low scores suggest positive moods. There was a significant group by time interaction on the POMS Total Mood Disturbance (TMD) score, $F_{1,26} = 6.75$, $p < 0.002$, $\text{Eta}^2 = 0.438$, with regular exercisers reporting a steady reduction (improvement) in total mood scores from baseline through to 25 minutes post-exercise. Conversely,

non-regular exercisers reported an initial increase (worsening mood) on the POMS (TMD) from pre-test to 10 minutes post-exercise, followed by a return to pre-test scores at 25 minutes. Similar patterns of mood change over time were observed on the six POMS subscales. Post-hoc analyses using POMS total scores indicated that regular exercisers reported significantly better mood states at baseline ($p < 0.01$, Cohen's $d = 1.11$), pre-test ($p < 0.05$, Cohen's $d = 0.76$), 10 minutes post-exercise ($p < 0.001$, Cohen's $d = 1.28$), and 25 minutes post-exercise ($p < 0.001$, Cohen's $d = 0.96$). Two of the POMS subscales showed a significant group by time interaction (Vigor, $F_{1,26} = 4.221$, $p = .015$, Fatigue, $F_{1,26} = 8.340$, $p < 0.001$). The remaining four subscales showed no interaction, but significant main effects of time (tension, $F_{1,26} = 18.15$, $p < 0.001$, $\text{Eta}^2 = 0.089$; depression, $F_{1,26} = 11.24$, $p = 0.002$, $\text{Eta}^2 = 0.061$; anger, $F_{1,26} = 7.36$, $p = 0.011$, $\text{Eta}^2 = 0.012$; and confusion, $F_{1,26} = 6.03$, $p = 0.021$, $\text{Eta}^2 = 0.089$) (see Figure 4).

State-Trait Anxiety Inventory

Figure 5 shows changes over time in state and trait anxiety (STAI) between regular and non-regular exercisers. High scores on the STAI indicate higher levels of self-reported anxiety, while low scores suggest lower anxiety levels. Analysis of co-variance results indicated a significant group by time interaction for state anxiety, $F_{1,26} = 5.47$, $p = 0.005$, $\text{Eta}^2 = 0.387$, but only a significant main effect of group for trait anxiety, $F_{1,26} = 7.72$, $p = 0.010$, $\text{Eta}^2 = 0.105$. For regular exercisers, state anxiety scores

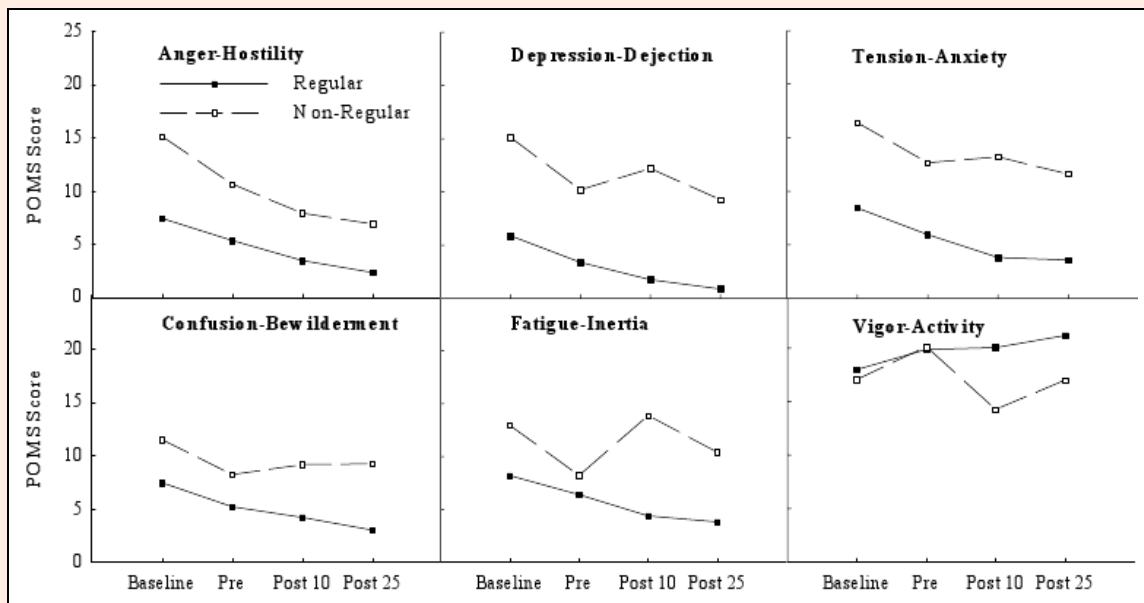


Figure 4. POMS subscale scores for regular and non-regular exercisers across time.

decreased from baseline to pre-test, and from pre-test to 10 and 25 minutes post-exercise. Non-regular exercisers also reported an initial decrease in state anxiety, but this was followed by a sharp increase from pre-test to 10 minutes post-exercise, and then a gradual reduction back to pre-test levels at 25 minutes. Post-hoc analyses indicated that regular exercisers reported significantly lower state anxiety at 10 minutes ($p < 0.01$, Cohen's $d = 1.87$) and 25 minutes ($p < 0.05$, Cohen's $d = 1.02$) post-exercise, respectively.

Discussion

Participation in regular exercise is associated significant physical and psychological benefits in both depressed (Barbour et al., 2007; Dunn and Dishman, 1991), and non-clinical populations (Boutcher et al., 1997). Research has also shown that the mood states associated with acute exercise can predict future exercise adherence (Williams

et al., 2008). Novice exercisers may be less skilled at self-regulating their own exercise intensity levels, leading to over-exertion during the early stages of a new exercise program. This may result in negative mood states following acute exercise and, in turn, poor long-term exercise adherence. While many investigations have explored the effects of acute exercise on mood, including the mediating role of fitness or previous exercise participation (Bixby and Lochbaum, 2006; Daley and Welch, 2003; Reed et al., 1998; Steptoe et al., 1993) there is active discussion in the literature regarding the mood enhancing effects of different exercise intensities among regular and non-regular exercisers (Ekkekakis et al., 2005; Lind et al., 2008). We therefore set out to examine the self-reported mood altering effects of a single bout of vigorous exercise among both regular and non-regular exercisers.

Our findings support the hypothesis that regular exercise participation is associated with significant improvements in mood following acute exercise, even when

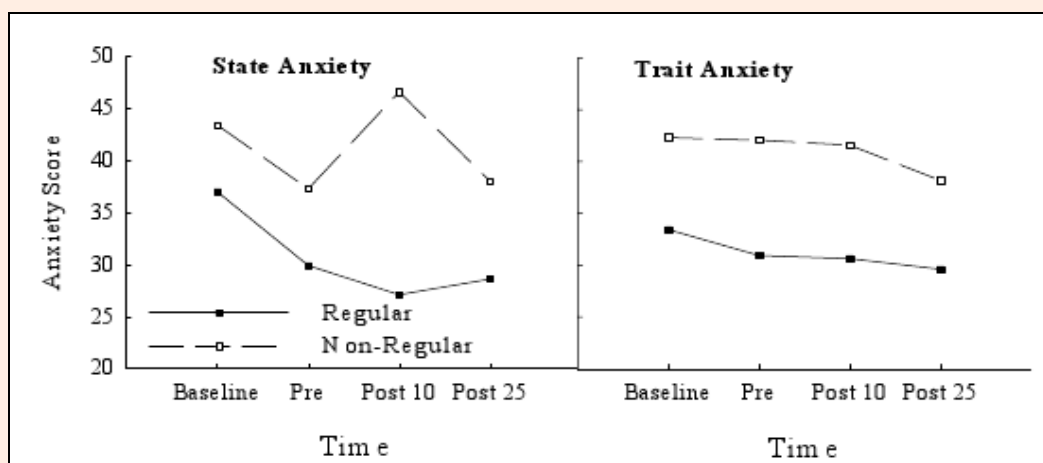


Figure 5. State and trait anxiety scores for regular and non-regular exercisers across time.

the exercise test is short and intense. Improvements in mood over time were reported by regular exercisers on both the Exercise Feeling Inventory (EFI) and Profile of Mood States questionnaire (POMS). Conversely, non-regular exercisers reported more negative mood states, including greater Fatigue, less Vigor and more Physical Exhaustion, demonstrating that intense physical exercise is not well tolerated (or desired) by novice exercisers, while the converse appears to occur for regular exercisers. Clearly, when it comes to exercise, some individuals like it vigorous while others do not, and this preference is mediated by previous exercise involvement. The POMS subscales revealed that post exercise mood changes are accompanied by transitory cognitive changes. In the present study, vigorous exercise was associated with greater feelings of Depression-Dejection and Confusion-Bewilderment by the novice exercisers, while the reverse was true for regular exercisers, suggesting that the two groups experienced the physical sensation of vigorous exertion in a dramatically different way, despite both groups cycling to the point of volitional exhaustion.

Previous studies have reported that acute bouts of exercise can significantly reduce state anxiety (Knapen et al., 2009; Smits et al., 2008). These findings were also confirmed, with regular exercisers reporting a decline in state anxiety across all four time points, compared to the non-regular exercisers, who reported an increase in state anxiety followed by a return to pre-test scores at 25 minutes. The rebound to pre-test mood and state anxiety levels by non-regular exercisers indicates a relatively fast recovery from the exercise session, and also demonstrates that the timing of the post-exercise mood questionnaire can dramatically influence the results obtained (see Figure 1).

The improved baseline mood scores (POMS) and lower trait anxiety scores reported by regular exercisers, support previous research indicating that participation in regular exercise brings about long term physiological and psychological changes which enhance mood and lower anxiety, compared to individuals who do not exercise regularly (Barbour et al., 2007; Dunn and Dishman, 1991). Several tenable psychological theories have been proposed to explain exercise-induced mood changes (eg, mastery, self-efficacy, and social interaction), and a number of equally tenable physiological theories (eg, monoamine changes, increased core body temperature, serotonin synthesis) (Dunn and Dishman, 1991). However, the precise interrelationship between these mechanisms remains poorly understood, and the focus of ongoing research (Bjørnebekk et al., 2005; Boecker et al., 2008).

Our results also have implications for exercise adherence. Although speculative, the post-exercise increase in negative mood states reported by non-regular exercisers suggests that exercise adherence for these individuals may be low if they experience unpleasant mood states following vigorous bouts of exercise. This indicates that exercise programs for beginners should avoid activities that are highly vigorous or likely to elicit negative emotional responses. By contrast, regular exercisers appear to

gain significant benefits, both psychologically and physically, from engaging in intense exercise, which may partly account for their continued adherence (Williams, 2008). It is likely that a cognitive component was involved here, with the regular exercisers interpreting the physical discomfort of maximal exercise in a positive, challenging way, while the non-regular exercisers may have felt overly challenged and anxious due to the relatively unfamiliar sensations associated with intense physical exertion. The trends which emerged on the Exercise Induced Feeling Inventory (EFI) were almost identical to those obtained with the POMS. Both inventories revealed significant post-exercise improvements in mood, and decreases in anxiety among regular exercisers. However, the difference reported between regular and non-regular exercisers were more apparent on the EFI (total) than on the POMS total mood disturbance scores, suggesting that the EFI could be a more sensitive measure of post-exercise mood change than the POMS.

Our hypothesis that participants would feel more anxious immediately before the exercise test compared to baseline, thereby confounding the post-exercise test results with inflated pre-test anxiety levels, was not confirmed. On the contrary, self-reported state anxiety *reduced* from baseline (measured 24 hours before the exercise test) to pre-test in both groups. As all the participants were university students, and the testing scenario occurred during normal university hours, one possible explanation for this finding is that participants viewed the task as an enjoyable distraction or 'time out' from routine study obligations. However, this innovation in the study design should be replicated in future investigations to exclude the possible confounding effects of inflated pre-test mood and anxiety scores.

There are some limitations to the present study which are acknowledged. First, we did not include a matched, non-exercise control group, which would allow stronger assertions about the effect of the exercise intervention on mood and anxiety. Second, we did not compare the effects of multiple exercise intensities, or self-selected exercise, on mood and anxiety. Ongoing research suggests that self-selection of exercise intensity may influence affective responses to acute exercise (Ekkekakis et al., 2005; Williams, 2008). It is possible that the exercise session used here was simply too intense for the non-regular exercisers to elicit a positive affective response and this possibility was not tested with a self-selected or multiple exercise testing procedure. Measuring perceived exertion would clarify whether the non-regular exercisers *perceived* the same exercise bout (volitional exhaustion) to be more strenuous than the regular exercisers. Another limitation concerns the population used and the external validity of laboratory based ('synthetic') exercise interventions. As only young people were involved in this study, we cannot assume the findings are equally valid for older individuals. We also recognize that exercise performed in a laboratory setting (and at high intensity) may induce a different affective response to exercise performed in everyday settings that are more familiar to the

participants. Future studies should explore the effect of various exercise modalities (eg, running versus cycling) conducted in different settings (eg, the laboratory versus outdoor). Exploring the influence of other variables, such as personality, health status, and exercise expectations within a single study will enhance our understanding of how these factors interact to influence post-exercise mood states. Finally, the short (6 item) version of the POMS is recommended over the 65 item version because it is more amenable to multiple administrations.

Conclusion

In conclusion, our findings indicate that previous exercise participation mediates the affective response to vigorous bouts of exercise. The post-exercise improvements in mood reported by regular exercisers indicate steady increases in positive mood states. Conversely, non-regular exercisers reported an initial decline in mood states, and transient increased post-exercise anxiety. These differences suggest that regular exercise induces psychobiological changes which mediate the affective response to acute bouts of vigorous exercise, which may in turn influence future exercise adherence. To maximise positive mood states, especially among novice exercisers, practitioners should carefully consider previous exercise participation when prescribing new exercise regimes.

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Key points

- Previous exercise participation mediates the affective response to acute bouts of vigorous exercise.
- Regular exercisers respond positively to acute bouts of vigorous physical activity, reporting less state anxiety and fatigue, and more vigour.
- Non-regular exercisers respond with an initial reduction in positive mood states, followed by a rebound to baseline levels 25 minutes post-exercise.
- To maximise positive post-exercise mood states, especially among novice exercisers, practitioners should carefully consider previous exercise participation when prescribing new exercise regimes.

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