

RELATIONSHIPS AMONG LEVEL OF PHYSICAL ACTIVITY,  
EXERCISE INTENSITY, MOOD, AND  
BETA-ENDORPHINS

by

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## INTRODUCTION

Physical inactivity is a prevalent public health problem in the United States. Many interventions aimed at increasing the percent of the population who are physically active have failed. As a result, the majority of the population is sedentary or inadequately active. Inactivity combined with the increasing abundance of high fat and high sugar foods found in fast food and other restaurants puts many individuals on the fast track to obesity. In order to remain healthy it is important to engage in the appropriate amount of exercise on a regular basis. However, most people choose not to be active for a variety of reasons, one of which is that exercise causes displeasure.

## REVIEW OF LITERATURE

It is a universal truth that people prefer to engage in activities that bring them joy, pleasure, and satisfaction. Choice of leisure-time activities depends on how the activity will make the individual feel. A person is more likely to partake in a recreation that is enjoyable and relaxing than one that causes displeasure. As a result, exercise is often bypassed because it can be taxing, frustrating, and unpleasant. Dishman et al.<sup>[15]</sup> wrote that “feelings of enjoyment and well-being seem to be stronger motives for continued participation [in exercise] than knowledge of and belief in the health benefits of physical activity” (pg 162). The affective response of exercise is significant to motivation and adherence.

### **Impact of Mood Response to Exercise on Adherence**

Recently, direct evidence between mood response to exercise and subsequent adherence has emerged<sup>[34,44]</sup>. Kwan and Bryan<sup>[34]</sup> analyzed positive

affect, negative affect, tranquility, and fatigue in adults during and after a 30-minute bout of treadmill exercise at 65% maximal oxygen uptake ( $VO_{2max}$ ). Larger increases in positive affect and decreases in fatigue during exercise were associated with more frequent self-reported exercise 3 months later. Schneider et al.<sup>[44]</sup> assessed pleasure while adolescents exercised on a cycle ergometer for 30 minutes at 80% of their ventilatory threshold workload. Those who reported increases in pleasure averaged 54.25 minutes of daily moderate-to-vigorous physical activity while those who reported no change averaged 46.94 minutes and those who reported declines averaged 38.83 minutes. Schneider et al.<sup>[44]</sup> concluded that increased pleasure facilitated longer activity sessions. Specifically, he predicted 4.18 minutes of additional daily physical activity in participants who reported increases in pleasure.

These findings suggest that a change in mood during and after exercise could have an impact on whether individuals adhere to an exercise program. Increases or decreases in pleasure and feeling state may contribute to the formation of positive or negative memories about exercise. These memories may then influence future decisions regarding whether to partake in, adhere to, or discontinue an exercise program<sup>[19]</sup>.

### **Exercise Intensity**

Intensity is a key component of physical activity. It is important to perform exercise at the appropriate intensity in order to gain the cardiovascular benefits exercise can provide. According to the American College of Sports Medicine (ACSM),<sup>[3]</sup> intensity is both “the most important exercise prescription variable to

maintain a cardiovascular training response” (p 161) and is “associated with an increased risk of orthopedic injury [and] cardiovascular incidence” (p 147). It is crucial to exercise at the appropriate intensity in order to avoid injury and increase health benefits.

Intensity may also play a role in adherence to an exercise program.

According to ACSM,<sup>[3]</sup> “adherence is lower with higher-intensity exercise programs” (p 142). It is logical to assume that individuals are more likely to maintain a program they enjoy. Generally, the more taxing a task is the less enjoyment is gained. However, past research studying the affect of intensity on short-term changes in mood, anxiety, and affect differ in their conclusions<sup>[2,11,12,13,30,36,37,40,46,48]</sup>.

### **Low Intensity**

The evidence supporting greater improvements in affect after acute bouts of low-intensity (LI) exercise compared to acute bouts of high-intensity (HI) exercise was provided by a study performed by Steptoe and Cox<sup>[48]</sup>. They compared the effects of music and intensity on pre- to post-exercise mood states in fit and unfit women using a modification of the Profile of Mood States (POMS)<sup>[39]</sup>. Of the independent variables, only intensity had a significant effect on mood. Participants reported increased vigor and exhilaration and decreased fatigue after LI bouts while HI bouts resulted in increased tension/anger and fatigue.

Since the study performed by Steptoe and Cox<sup>[48]</sup>, several other studies have supported their conclusion regarding intensity<sup>[2,30,36,37]</sup>. Acevedo et al.<sup>[2]</sup> performed graded exercise treadmill tests on runners, administering the Visual Analog Mood Scale (VAMS)<sup>[49]</sup> at the end of each interval. Affect was unchanged from 60-75%

VO<sub>2</sub>max but significantly changed toward “apprehension” from 75-90% VO<sub>2</sub>max. Katula et al.<sup>[30]</sup> compared light, moderate, and maximal exercise in sedentary older adults and found decreased anxiety with LI and increased anxiety with maximal intensity as measured by the State Anxiety Inventory (SAI)<sup>[47]</sup>. McAuley et al.<sup>[37]</sup> performed a comparable study to the one by Katula et al.<sup>[30]</sup> but administered the Subjective Exercise Experiences Scale (SEES)<sup>[38]</sup> instead of the SAI. Participants reported improved scores on each component of the SEES (positive well-being, psychological distress, and fatigue) after low-intensity bouts compared to high-intensity bouts. Each of these studies reported increases in positive mood and decreases in negative mood following low intensity exercise, with opposite phenomena following high intensity exercise.

### **High Intensity**

In contrast, several studies report a greater improvement in mood after acute bouts of high-intensity exercise compared to low-intensity exercise<sup>[11,12,40]</sup> or no difference in affect between intensities<sup>[13,18,32,46]</sup>. Cox et al.<sup>[12]</sup> found a higher intensity effect on positive well-being following a bout of treadmill exercise at 80% VO<sub>2</sub>max compared to 60% VO<sub>2</sub>max, but no difference between intensities for fatigue and psychological distress. Oweis and Spinks<sup>[40]</sup> administered the Activation Deactivation Adjective Check List (AD ACL)<sup>[50]</sup>, a measure of arousal states, immediately after acute bouts of light (45% VO<sub>2</sub>max - LI), moderate (60% VO<sub>2</sub>max), and high (75% VO<sub>2</sub>max - HI) intensity stationary cycling and a control (zero resistance). Energetic arousal was lower after LI than control and higher after HI

than LI. Tense arousal was lower after HI than control and LI. Both results indicate a greater improvement in mood following the HI bout compared to the LI bout.

### **Determining Exercise Intensity**

With such inconsistent findings it is important to consider whether methodology could be impacting results. When determining the intensity at which study participants work, researchers have generally taken one of two approaches: 1) measure intensity by percentage of maximum heart rate (MHR) or  $VO_2\text{max}$  or 2) use ventilatory threshold (VT), lactate threshold (LT), or the point at which blood lactate accumulates (OBLA) as a cut-off point between low or moderate intensity and high intensity.

#### **Maximum Heart Rate and $VO_2\text{max}$**

Traditionally, the heart rate and  $VO_2\text{max}$  were more common and were used by the studies previously discussed; however, these studies are not consistent in the definition of low, moderate, and high intensity. Rationale for the determination of intensity was often not given. One study may have compared 40% to 70% MHR<sup>[46]</sup> while another compared 55% to 85% MHR<sup>[13]</sup>. In addition to varying the percentage, using MHR and  $VO_2\text{max}$  in different studies makes it difficult to compare results. It is necessary to convert one method of measurement to the other and meaning can get lost in translation. The lack of a universal definition of varying intensities in terms of percentage of MHR or  $VO_2\text{max}$  and the contradictory evidence supporting both LI and HI as a more effective means of improving mood after exercise discredits this method of determining intensity.

## **VT/LT/OBLA**

More recent studies used VT, LT, or OBLA as physiological markers to compare with changes in mood<sup>[5,6,9,18,32,33,41,43]</sup>. Setting the relation of intensity to a physiological marker reflects the contributions of aerobic and anaerobic metabolic pathways. Results of research using VT, LT, or OBLA are more consistent in their findings than when percentage of MHR or VO<sub>2</sub>max is manipulated. Most of these studies also measured mood disturbance during exercise bouts in addition to comparing pre- and post-changes, enabling researchers to better understand how different levels of intensity affect mood over time.

### **Affective Responses to Exercise**

#### **Graded Exercise Tests**

Measuring mood disturbance during exercise provides valuable insight into the point at which exercise goes from tolerable to intolerable. Several studies performing graded exercise tests indicate that once an individual passes his/her VT, LT, or OBLA mood begins to decline<sup>[1,17,25,26,45,52]</sup>. During these tests, the intensity of exercise increases at pre-designated intervals until the individual reaches exhaustion. The test is terminated when at least three of the following criteria are met: subject attains age-predicted heart rate, VO<sub>2</sub> levels off with increasing workload, Respiratory Exchange Ratio is 1.1 or greater, blood lactate is 8.0 mmol/L or higher, or the subject voluntarily terminates the test.

In 2002 Hall et al.<sup>[25]</sup> performed graded exercise treadmill tests on college students, administering the Feeling Scale (FS)<sup>[28]</sup> every minute during exercise. During the test, FS declined but the change was only significant starting with the

minute after VT and until test termination. Hall and colleagues<sup>[26]</sup> performed another graded test on college students in 2004, this time on recumbent cycling, and reported similar results, which were consistent across gender and age<sup>[45,52]</sup>. Welch et al.<sup>[52]</sup> measured changes on the Feeling Scale<sup>[28]</sup> in 20 inactive females during a max test and reported declines in FS were larger from the minute after the VT to the end. Sheppard and Parfitt<sup>[45]</sup> studied sedentary men and boys and found significant decreases in FS after the VT as well. These studies showed that exercise intensities below VT, LT, and OBLA usually do not have a negative impact on during-exercise affective states. In contrast, when the intensity exceeds these physiological landmarks there is a negative effect on mood.

### **Acute Bouts of Exercise**

Declines in pleasure beyond the VT, LT, or OBLA were also found in studies that compared acute bouts performed at intensities below and above the threshold<sup>[6,33,41,43]</sup>. Furthermore, the study of acute bouts revealed differences in how mood altered from pre- to during exercise compared to pre- to post-exercise<sup>[5,6,18,33]</sup>. In 2001 Bixby et al.<sup>[6]</sup> administered the Visual Analog Mood Scale (VAMS)<sup>[49]</sup> 15, 10, and 5 minutes before, 10, 20, and 30 minutes during and 10, 20, and 30 minutes after 30 minute bouts of low (75% of HR at VT) and high (just below HR at VT) intensity stationary cycling in college students. The VAMS consists of seven schematic faces representing the following mood states: sad, afraid, angry, tired, energetic, happy, and confused. During LI cycling significant improvement did not occur until minute 20 of cycling and stayed elevated above baseline until minute 30 of recovery. During HI cycling scores were lower than baseline throughout the

bout but were better than all exercise time points during recovery. The two intensity conditions were different during exercise but not baseline and recovery. Both intensities resulted in mood improvements post-exercise but only the LI improved mood during exercise. Then in 2006 Bixby and Lochbaum<sup>[5]</sup> performed the same experiment with a different subjects of similar age to those in the previous study and administered the AD ACL<sup>[50]</sup> instead of the VAMS<sup>[49]</sup>. Results supported those found in 2001. There was a significant intensity by time interaction, with more positive affect during the LI condition but no differences during recovery.

### **During-Exercise Affect Response**

The study of during-exercise affect response provides valuable information regarding adherence to exercise programs. The majority of studies measuring mood changes in relation to physiological landmarks reported no differences in mood states between intensities during recovery<sup>[5,6,18,32,33,41]</sup>. The only differences between intensities were observed during exercise. These findings could explain why ACSM<sup>[3]</sup> finds “adherence is lower with higher-intensity exercise programs” (p 142). Once individuals reach a certain physiological point exercise causes negative mood disturbance. The short-term mood enhancement observed post-HI exercise might not compensate for the decrease in mood during the bout. Individuals remember the displeasure felt while exercising as opposed to the increase in positivity post-exercise.

The incremental tests have shown significant declines in during-exercise affect only begin when the participant reaches or exceeds the physiological marker<sup>[1,17,25,26,45,52]</sup> and studies performing acute bouts support this conclusion.

Findings utilizing VT, LT, or OBLA to determine intensity are more consistent than those achieved through studies employing MHR and VO<sub>2</sub>max. The general conclusion is that there is an inverse relationship between exercise intensity and affective-responses, a phenomenon that appears stronger among those studies that included assessments during exercise.

### **Impact of Fitness on Affective Response to Exercise**

The intensity-affect response could also be influenced by activity level. Studies show that those who exercise on a regular basis experience greater mood benefits during and after exercise than individuals who do not exercise regularly<sup>[5,27,29,35,36,51]</sup>. Hallgren<sup>[27]</sup> assessed responses to a questionnaire incorporating aspects of the Exercise-Induced Feeling Inventory (EFI)<sup>[20]</sup>, Profile of Mood States (POMS)<sup>[39]</sup>, and State-Trait Anxiety Inventory (STAI)<sup>[47]</sup> pre- and post-incremental ergometer tests to exhaustion in regular and non-regular exercisers. Improvements in positive engagement and revitalization (EFI) and decreases in fatigue (POMS) were reported by exercisers while non-exercisers reported opposite phenomena. These findings indicate that previous exercise participation mediates affective response to vigorous bouts of exercise, such as incremental tests to exhaustion.

In another study, Hoffman<sup>[29]</sup> compared non-exercisers, regular moderate exercisers, and ultra marathon runners. The participants completed the POMS<sup>[39]</sup> before and after performing a treadmill test at 60-90% MHR. Vigor increased and fatigue decreased in the runners only. Post mood disturbance decreased among all groups with the greatest change in ultra marathon runners. Exercisers reported

twice the mood improvement of non-exercisers. Experiments performed by Bixby<sup>[5]</sup> and Lochbaum<sup>[35,36]</sup> also found that fit individuals reported more positive affect than unfit individuals overall.

### **Comparison of Fitness at Different Intensities**

The above studies compared active and inactive individuals at one intensity level. Comparing responses to different intensities in individuals of varying fitness levels yields even more insight into the influence of affect on adherence patterns. Tieman et al.<sup>[51]</sup> studied state anxiety response changes following acute bouts of low and high stationary cycling and a quiet reading control in high and low active adults. Among low active, SAI<sup>[47]</sup> was lower after light cycling compared with quiet rest and hard cycling while SAI was unchanged in high active. Additional analyses examined SAI responses to a maximal cycling test. Among low active, SAI increased 5 minutes post-exercise compared with 60 and 5 minutes pre-exercise while scores were once again unchanged among high active. The high intensity bouts had a negative affect on the low active but no affect on high active. In addition, the low intensity produced decreases in state anxiety in the low active individuals. Tieman's findings propose that low active individuals cannot tolerate high intensity exercise, while high active individuals are not negatively affected by it.

### **Inactive Individuals and Low Intensity**

The findings of Tieman et. al<sup>[51]</sup> suggest that low fit individuals will benefit more from low intensity exercise than high intensity exercise. Several studies examining the effects of intensity on inactive individuals support these findings<sup>[30,37,41,43,45]</sup>. McAuley et al.<sup>[37]</sup> reported that in sedentary older adults,

positive well-being significantly increased after light exercise and decreased after maximal. Psychological distress decreased after light and increased after maximal. In addition, fatigue showed significant increases after moderate and maximal exercise. Welch et al.<sup>[52]</sup> measured responses to the Feeling Score (FS)<sup>[28]</sup> in inactive young females during and after a maximal test. While FS declined continuously during the test compared with minute 1, declines were larger from the minute after VT to the end. Similarly, Rose and Parfitt<sup>[43]</sup> found that FS was less positive in sedentary females performing at an intensity greater than their LT compared to intensities below and at LT. In the condition greater than LT, FS was also less positive post- than pre-exercise but there was no difference pre and post for all other conditions. The inactive subjects in these studies exhibited greater decreases in mood at increasing intensities, with the greatest decrements at intensities above VT. It would appear, therefore, that to receive positive mood benefits with exercise inactive individuals must work at low intensities.

### **Need for More Research**

There is a disparity in the research findings comparing intensity effects on fit to unfit individuals. Several studies report no effect of fitness on mood response<sup>[8,9,13]</sup>. In 2001 Blanchard et al.<sup>[8]</sup> examined mood response using the SEES<sup>[38]</sup> in fit and unfit females in their mid-20s before and after a 30-minute bout of stationary cycling. Fitness did not affect positive well-being or psychological distress. Similar findings were reported in a study by Daley and Welch<sup>[13]</sup>, in which active and inactive young adults participated in a 20-minute bout of treadmill exercise at 50-55% and 80-85% age-predicted MHR. The two groups did not differ

in mood disturbance. Then in 2004, Blanchard and his colleagues<sup>[9]</sup> performed a 12-week study on a group of community residents of varying fitness levels to determine long-term effects of exercise on mood. Results showed that fitness did not influence changes in positive well-being, psychological distress, or fatigue. These studies suggest that fitness level will not affect mood disturbance during or after exercise.

The contradictory data regarding the relationship between fitness level and the intensity-affect exercise chain highlights the need to direct more research to individuals who are not physically active. Preliminary findings show that most sedentary adults experience reduced pleasure during higher-intensity workloads, supporting ACSM's claim that adherence to exercise will be lower with high intensity programs. However, before this hypothesis can be readily accepted more evidence needs to be collected.

### **Effect of Study Environment**

It is possible that the setting in which these studies were executed could have confounded results. Most of the studies conducted took place in a laboratory setting using either running or walking on the treadmill or stationary or recumbent cycling as the means of exercise. The unfamiliar lab may have raised anxiety or stress and affected the outcome of the studies. However, studies directly comparing active to inactive individuals reported no difference in pre-exercise state anxiety between fitness groups. There was also no reported difference in mood assessment prior to the varying levels of intensity. Consequently, the laboratory setting may be ruled out as a confounding factor. Research into whether naturalistic settings have a more positive affect on mood than laboratory settings is limited<sup>[21,30,31,42]</sup>. Studies indicate

that healthy adults exhibit significant improvements in revitalization following high intensity exercise<sup>[21]</sup>, and reductions in anxiety, tension, depression, aggressiveness, and confusion following low intensity<sup>[30,42]</sup> in natural settings.

The duration of exercise for the studies comparing acute bouts ranged from 15 to 40 minutes, with the exception of Steptoe and Cox<sup>[48]</sup> who used four 8-minute bouts separated by at least 5 minutes of rest. The ratio of studies executing treadmill versus cycling tests is approximately 1:1 and findings are mostly consistent. Therefore it is safe to conclude that neither mode is better than the other in regards to reliability of results. This conclusion is supported by the two studies performed by Hall and his colleagues in 2002<sup>[24]</sup> and 2004<sup>[26]</sup>. The first study examined college students performing treadmill tests and the second studied college students performing recumbent cycling tests. Both experiments had the same basic design and measurements and reported similar findings, suggesting the two exercise modes are interchangeable.

Finally, participant groups should be considered. The majority of the studies described in this review used college- or middle-aged adults. Ages ranged from 18-44 years, with a few studies examining older adults in their mid-60s. Both males and females participated. No studies reported age or gender affecting results. In conclusion, the laboratory setting, mode and duration of exercise, and participant groups do not appear to confound the results of these studies.

### **Physiological Response to Exercise**

Mood is not the only factor to consider when evaluating the effect exercise has on an individual. There are several physiological features that change during

and after exercise. Some common responses include increased heart rate, blood flow, blood pressure, respiration, hormone release, and glucose breakdown.

Evaluation of physiological responses to exercise could serve as a tool in understanding the mechanisms behind the intensity-affect exercise chain.

### **$\beta$ -Endorphin Response**

One such mechanism being researched is the endorphinergic response.  $\beta$ -endorphin ( $\beta$ -E) is a member of the large family of opioid peptides distributed throughout the nervous system. Regulation of pain and reward and neurocircuitry involving learning and memory, motivation, stress, fear, and anxiety are linked with  $\beta$ -E<sup>[24]</sup>. Grisel et al.<sup>[24]</sup> examined the influence of  $\beta$ -E on stress response by monitoring anxious behavior in mice. A direct relationship was observed between  $\beta$ -E levels and measures of anxious behavior suggesting that  $\beta$ -E moderates the response to stressful stimuli. Studies exploring the relationship between endorphin release and exercise report two to five-fold increases in peripheral circulation of  $\beta$ -E following acute bouts of physical activity<sup>[4,14,22,23]</sup>. These observations suggest that increased endorphin release is at least partially responsible for the positive mood shift reported by exercisers.

The amount of  $\beta$ -E release with exercise is linked to the level of intensity<sup>[22,23]</sup>. Goldfarb et al.<sup>[22]</sup> measured changes in  $\beta$ -E levels during and after a bicycle ergometer test to  $VO_2$ max and at 60, 70, and 80%  $VO_2$ max for 30 minute bouts. The 60% intensity did not elevate  $\beta$ -E. At minute 15 of the 70% intensity there was a significant increase in plasma  $\beta$ -E and the 80% intensity showed an increase in  $\beta$ -E content as early as minute 5.  $\beta$ -E remained elevated 20 minutes into

recovery in the two higher intensity conditions. The study concluded that an intensity of 70%  $VO_{2max}$  is required for significant increases in  $\beta$ -E levels and that the higher the exercise intensity, the more rapid the increase. These results were supported by a similar experiment performed at a later date by Goldfarb and his colleagues<sup>[23]</sup>. In both experiments they observed that the concentration of  $\beta$ -E gradually increased over time during exercise. In contrast, Angelopoulos<sup>[4]</sup> reported an initial increase of  $\beta$ -E early on in a 30 minute bout of high intensity exercise (80%  $VO_{2max}$ ) but no further changes over time. However, the significant increases in  $\beta$ -E levels during intense exercise are consistent with the observations made by Goldfarb et al. It can be concluded that higher intensity exercise elicits greater release of  $\beta$ -E, and 70% of  $VO_{2max}$  is the minimum intensity for a significant rise in  $\beta$ -E levels.

### **Link Between Endorphins and Affect Response**

The increased levels of endogenous opioids (endorphins) observed in high intensity exercise may mediate exercise-induced mood shifts. Daniel et al.<sup>[14]</sup> assessed mood changes using the POMS before and after a 75-minute high intensity aerobics class. Participants were given naltrexone, an opiate receptor blocker, or a placebo pre-exercise. Mood states became more pleasant, relaxed, and peaceful, tending away from tension, depression, anger, fatigue, and confusion in individuals given the placebo. In contrast, participants preloaded with naltrexone did not report an overall positive mood shift, suggesting that exercise-induced mood changes are mediated through endorphinergic mechanisms.

Most researchers investigating  $\beta$ -E release during exercise have measured the amount found in peripheral blood. These levels cannot be tied concretely to central nervous system (CNS) effects because endorphins have a small rate of success of bypassing the blood-brain barrier to reenter the brain. In order to relate exercise-induced endogenous opioidergic release to mood changes, Boeker et al.<sup>[10]</sup> performed a positron emission tomography (PET) scan to compare binding of the nonselective opioidergic ligand 6-O-(2-[<sup>18</sup>F]fluoroethyl)-6-O-desmethyldiprenorphine ([<sup>18</sup>F]FDPN) under rest and strenuous exercise. Since this ligand labels three different opioid receptors in a nonspecific way, Boeker could not conclude which opioid dominates the opioidergic effects. Even so, results supported the hypothesis that opioids encourage a positive mood shift post-strenuous activity. The trained runners participating in the experiment reported a significant increase in euphoria and happiness post-run compared with rest, measured with VAMS. The euphoria ratings were inversely correlated with [<sup>18</sup>F]FDPN binding in the frontolimbic regions of the brain, which are pivotal for the generation of affect and mood states. This suggests that the differential release of endogenous opioids in relation to perceived euphoria is likely responsible for the increase in positive mood known as the “runner’s high.” Since this study measured levels of opioid binding directly in the CNS as opposed to indirectly through peripheral blood content it provides more reliable evidence of the theory that endorphins mediate affective response to strenuous exercise.

## Summary and Project Significance

Research on the effect of exercise on mood state began in the late 1980s. While initial studies produced contradictory results, recent studies using VT, LT, or OBLA have reported more consistent findings. Participants, regardless of fitness level, show a negative affect response when exercise passes VT, LT, or OBLA. Individuals who engage in exercise on a regular basis report greater overall mood enhancement during and following exercise compared to individuals who do not exercise regularly. In addition, light intensity exercise appears to induce less of a negative mood shift in inactive individuals than high intensity exercises.

Physiological characteristics are also affected by varying intensities of physical activity.  $\beta$ -E response increases gradually over time when an individual exercises above 70% of his/her  $VO_2$ max. The rise in peripheral  $\beta$ -E levels is implicated in improvements in mood state during and post exercise and is therefore a possible physiological mechanism mediating the intensity-affect exercise chain.

There is a need for more information about the relationship between exercise and inactive individuals. A majority of the American population does not engage in the amount of physical activity and exercise recommended by ACSM. Therefore, further investigating the impact exercise intensity has on mood will help fitness professionals better understand how best to motivate clients to adhere to an exercise program. In addition, exploring the link between the psychological and physiological effects of exercise will shed light on the mechanisms behind the intensity-affect exercise chain.

## **Purpose and Hypotheses**

The purpose of this investigation is to examine how intensity level of acute bouts of exercise affects mood states in active versus inactive individuals and to compare these changes to peripheral  $\beta$ -endorphin levels post-exercise. The hypotheses for this study are as follows:

1. Individuals who participate in exercise on a regular basis will achieve greater positive mood benefits than those who do not exercise regularly across all intensity levels.
2. Individuals who do not exercise regularly will achieve greater positive mood benefits from low intensity exercise compared to high intensity exercise.
3. Higher  $\beta$ -endorphin levels will correspond to greater increases in positive mood after exercise.

## **METHODS**

### **Participants**

Participants were 12 volunteer, college students. All participants were recruited via advertisements in the Kinesiology Department of TCU. The participants were divided into two groups: six regularly active individuals and six inactive individuals, as defined by ACSM's guidelines for exercise. Regularly active individuals were operationally defined as those who perform exercise at least five times a week for at least 30-minute durations at moderate or high intensities. Inactive individuals were operationally defined as those who perform exercise once a week or less for 30 minutes or less at low or moderate intensities. Participants

were placed in one of the above categories according to responses to a Physical Activity Questionnaire completed during the first visit to the lab.

### **Experimental Design**

The experiment involved testing based on three independent factors: activity level, exercise intensity, and time course responses before and after the bouts of exercise. Subjects were divided into the two activity level groups. Each group completed a bout of low-intensity (LI = 10% of  $VO_{2max}$  below ventilatory threshold) and high-intensity (HI = 5% of  $VO_{2max}$  above ventilatory threshold) exercise on a treadmill on different days. Changes in affect and post-exercise endorphin levels were measured. The Subjective Exercise Experiences Scale (SEES)<sup>[38]</sup> was used to assess affect. The three subscales measured were Positive Well-Being, Psychological Distress, and Fatigue. The SEES was administered immediately prior to and after each exercise bout. The physiological response measured in this experiment was level of plasma beta-endorphins ( $\beta$ -E) from blood samples obtained immediately after each exercise bout.

### **Preliminary Testing**

During the first visit to the lab subjects completed all necessary paperwork to participate in the experiment, i.e., Informed Consent, Medical History, HIPPA, and Physical Activity Questionnaire. Subjects were classified as either “regularly active” or “inactive” according to responses to the activity questionnaire. Anthropometric measures were taken, including height, weight, age, and a body composition assessment via a four-site skinfold method. Finally, participants completed a graded exercise test to exhaustion on a treadmill to determine  $VO_{2max}$ . During this test

treadmill speed and incline were increased every 3 minutes until  $VO_2\text{max}$  was reached. A valid test was determined by the presence of at least two of the following criteria: the inability to maintain the treadmill speed, achieving an age-predicted maximal heart rate, reaching a respiratory exchange ratio of 1.10 or greater, and the leveling off of the  $VO_2$  response with an increase in treadmill speed or grade. The starting speed was individualized based on the participant's running background and capabilities. Each subject's ventilatory threshold (VT) was then defined as the percentage of aerobic capacity associated with an upward deflection in  $VE/VO_2$ . LI bouts of exercise were defined as 10% of  $VO_2\text{max}$  below the VT. HI bouts of exercise were defined as 5% of  $VO_2\text{max}$  above the VT. Individual target treadmill speeds corresponding to these exercise intensities were calculated.

### **Experimental Testing**

On the second and third visits subjects completed a 20-minute bout of treadmill running of LI or HI, as calculated using VT. The order of exercise intensities was randomly assigned and counterbalanced across participants. Except for exercise intensity, the following procedures on the second and third days were identical. Participants completed the SEES<sup>[38]</sup> then immediately began walking or running on a treadmill. The speed and grade of the treadmill was adjusted to induce a work output corresponding to each subject's target intensities as previously described. During the treadmill runs, heart rate was monitored continuously, and  $VO_2$  was determined during the first 5 minutes and the last 3 minutes to verify the exercise intensity. Following completion of the exercise bout a 5-mL blood sample

was taken from the antecubital vein. Participants then completed the SEES for a second time.

### **Blood Analysis**

The 5-mL blood samples were each centrifuged immediately following extraction. Plasma was removed and stored at  $-80^{\circ}\text{C}$ . Once all samples were obtained from each subject for each bout of exercise, an ELISA was used to analyze the beta-endorphin levels by following the manufacturer's procedures. The procedure required that plasma samples were first incubated for one hour at  $37^{\circ}\text{C}$  in a microtitre plate well coated with the primary antibody for beta-endorphins. The wells were then washed and incubated for another 15 minutes at  $37^{\circ}\text{C}$  with a conjugated substrate for horseradish peroxidase (HRP) enzyme. Finally, a stop solution was added to the wells, changing the complex color from blue to yellow. The intensity of color, as measured spectrophotometrically was inversely proportional to the beta-endorphin concentration.

### **Affect Analysis**

The Subjective Exercise Experiences Scale<sup>[38]</sup> is a 12-item scale assessing three general categories of subjective responses to exercise stimuli: Positive Well-Being (PWB), Psychological Distress (PD), and Fatigue (FAT). Internal consistency was established among the three subscales: PWB  $\alpha = .86$ , PD  $\alpha = .85$ , and Fatigue  $\alpha = .88$ . Convergent and discriminatory validity were obtained by comparing this new instrument to preexisting tools. Results demonstrated adequate levels of validity. Each of the three categories consists of four items. For each item participants rated how strongly they were experiencing each feeling state "now, at this point in time"

along a 7-point Likert scale, ranging from 1 (not at all) to 7 (very much so). Total scores for each subscale could fall within the range of 4-28.

### **Statistical Analysis**

A three-factor analysis of variance (ANOVA) was used to determine differences between groups (regularly active and inactive), between conditions (LI and HI), and over time (different sampling points). Dependent variables were blood plasma beta-endorphins and mood via the SEES. In addition, Pearson correlation analyses were conducted to determine relationships between dependent variables, collapsing across groups. An alpha level of  $p < 0.05$  was accepted for all analyses.

### **RESULTS**

Selected subject characteristics are shown in Table 1. As expected, percent body fat was lower and  $VO_2$ max values were higher in the active group compared to the inactive group. Frequency and duration of regular activity was higher in the active group. Exercise bouts ranged from 45-180 minutes in the active group and 30-60 minutes in the inactive group. Inactive individuals reported engaging in the activities of walking, racquetball, light resistance training, yoga, and jogging at self-rated intensities of “moderate” to “strong.” Active individuals engaged in resistance training, running, basketball, swimming, racquetball, and dance at self-rated intensities of “strong” to “very strong.” In addition, most active individuals performed multiple types of activities throughout a week.

**Table 1.** Means (standard deviations) for selected subject characteristics. (a) Values for the inactive group. (b) Values for the active group and all participants (ALL).

a)

INACTIVE	M (n=2)	F (n=4)	TOTAL (n=6)
Age (years)	22.5	21.25	21.9
Height (in)	70.5 (2.12)	67.3 (1.5)	68.9 (1.81)
Weight (lb)	172.5 (3.54)	148 (19.3)	160.3 (11.42)
Body Comp (% fat)	17.5 (4.95)	27 (3.27)	22.3 (4.11)
VO <sub>2</sub> max (mL/kg/min)	42.7 (8.91)	38.2 (6.73)	40.5 (7.82)
Activity frequency (days/wk)			1.5 (0.55)
Activity duration (min/bout)			37.5 (12.55)

b)

ACTIVE	M (n=2)	F (n=4)	TOTAL (n=6)	ALL (n=12)
Age	20.5	20.8	20.6	21.25
Height (in)	74 (1.41)	64.5 (1)	69.3 (1.21)	69.1 (1.51)
Weight (lb)	155 (7.07)	124 (13.49)	139.5 (10.28)	149.9 (10.85)
Body Comp (% fat)	8 (2.83)	20 (4.24)	14 (3.54)	18.1 (8.82)
VO <sub>2</sub> max (mL/kg/min)	45.9 (4.38)	43.5 (6.97)	44.7 (5.68)	42.6 (6.75)
Activity frequency (days/wk)			5.0 (0.80)	
Activity duration (min/bout)			75.0 (51.96)	

Relative VO<sub>2</sub> values and percentage of VO<sub>2</sub>max for each condition are reported in Table 2. LI was defined as 10% of VO<sub>2</sub>max below VT and HI was defined as 5% of VO<sub>2</sub>max above VT. Both groups had a mean of 66% VO<sub>2</sub>max for LI and 83% VO<sub>2</sub>max for HI. Relative VO<sub>2</sub> values were higher in the active group compared to the inactive group, as expected.

**Table 2.** Means (standard deviations) for relative intensities of exercise bouts.

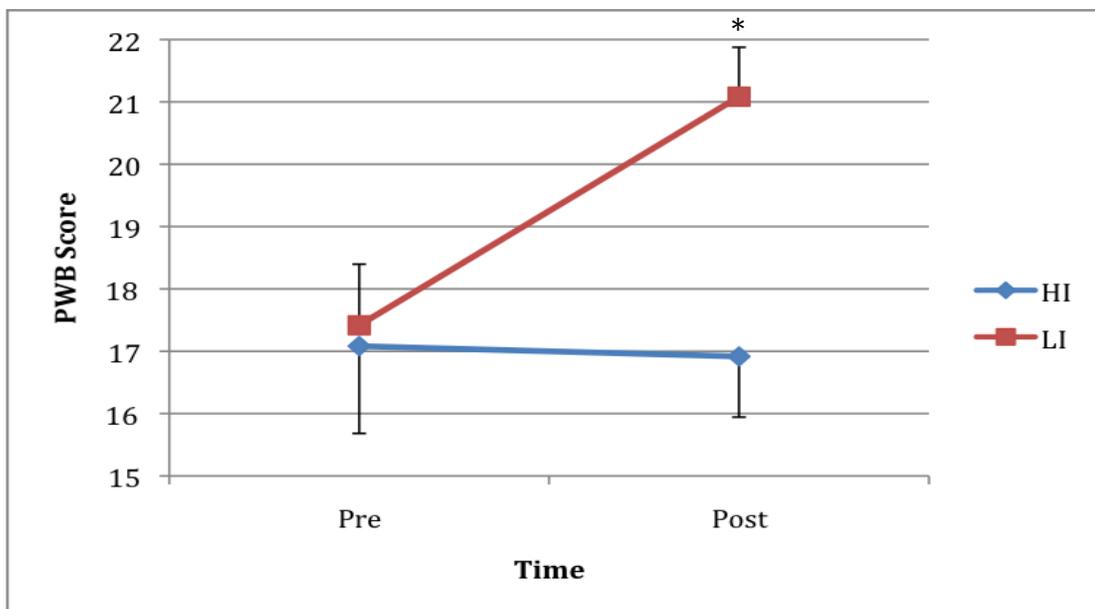
Group	Low Intensity		High Intensity	
	VO <sub>2</sub> (mL/kg/min)	% VO <sub>2</sub> max	VO <sub>2</sub> (mL/kg/min)	% VO <sub>2</sub> max
Inactive	26.87 (3.77)	66 (5.14)	34.28 (5.28)	83 (5.43)
Active	29.30 (4.30)	66 (1.74)	37.07 (4.53)	83 (2.42)

The three mood responses measured were Positive Well-Being (PWB), Fatigue (FAT), and Psychological Distress (PD). Means and standard deviations for the mood variable are listed for each group and condition in Table 3. There were no

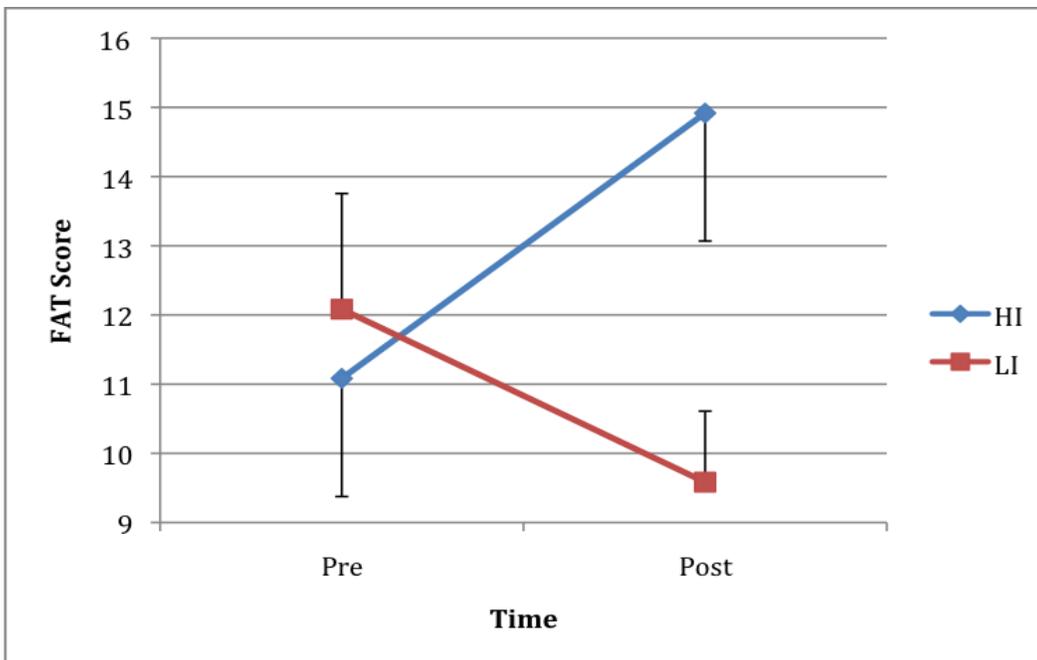
differences between groups for any mood variable. A significant intensity by time interaction was observed for PWB ( $p=0.03$ ; Figure 1). Differences in FAT and PD scores did not reach significance, but a trend was observed for both variables. There was a tendency towards an intensity by time interaction for FAT ( $p=0.07$ ; Figure 2) and a time by group interaction for PD ( $p=0.09$ ; Figure 3).

**Table 3.** Means (standard deviations) for mood variables.

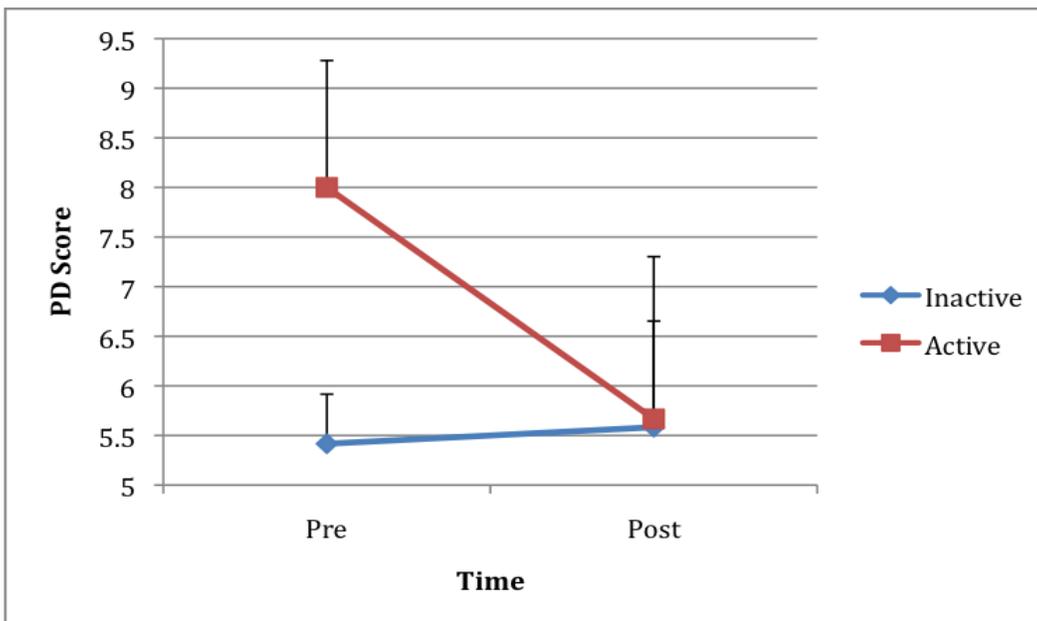
	Time	PWB		PD		FAT	
		HI	LI	HI	LI	HI	LI
INACTIVE	Pre	15.7 (3.39)	17.3 (3.14)	5.3 (1.97)	5.5 (1.64)	10.3 (5.85)	11.2 (5.19)
	Post	15.8 (3.97)	20.7 (2.66)	6.8 (5.12)	4.3 (0.52)	15.7 (4.32)	9.8 (3.97)
ACTIVE	Pre	18.5 (5.96)	17.5 (3.94)	7.8 (4.71)	8.2 (5.48)	11.8 (6.43)	13.0 (6.69)
	Post	18.0 (2.53)	21.5 (3.02)	5.5 (3.21)	5.8 (2.99)	14.2 (8.38)	9.3 (3.44)



**Figure 1.** Positive well-being scores pre and post high and low intensity bouts, collapsed across groups. \*Significant difference between post-scores for high and low intensity ( $p=0.01$ ). Values are mean  $\pm$  SE.



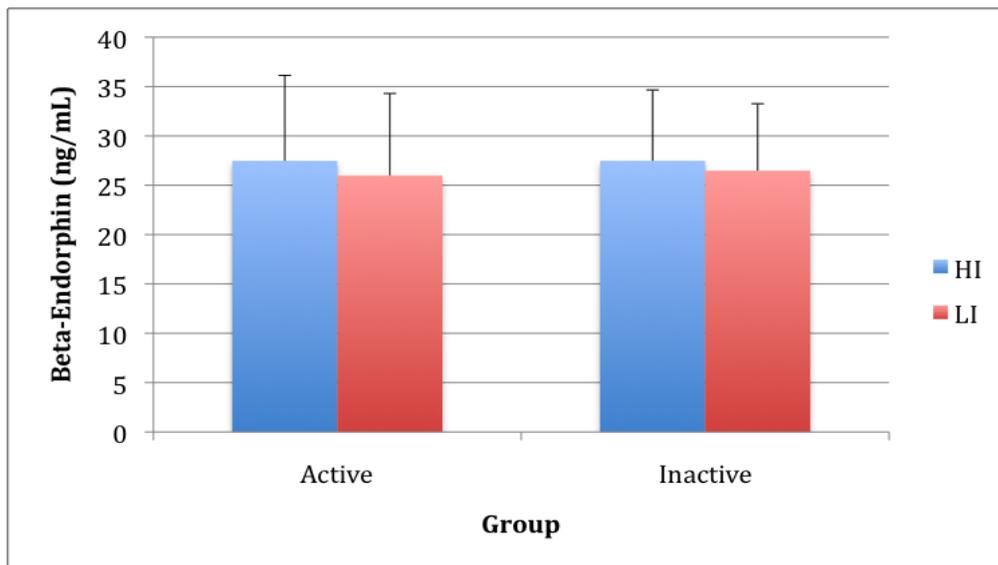
**Figure 2.** Fatigue scores pre and post high and low intensity bouts, collapsed across groups. Values are mean  $\pm$  SE.



**Figure 3.** Psychological distress scores pre and post exercise, collapsed across intensities, for Inactive and Active groups. Values are mean  $\pm$  SE.

The  $\beta$ -E levels did not vary significantly between conditions, but a tendency towards an intensity effect was observed ( $p=0.1$ ; Figure 4). When correlating  $\beta$ -E and affect, changes in affect pre- to post-exercise bout were used to account for

differences in absolute values between subjects, and are denoted as  $\Delta$ PWB,  $\Delta$ FAT, and  $\Delta$ PD. Correlations between  $\beta$ -E and change in affect did not reach significance, but there were some moderately correlated variables. Specifically, a moderate correlation was observed between HI  $\beta$ -E levels and  $\Delta$ PWB ( $r=0.47$ ). There was no correlation between LI  $\beta$ -E and  $\Delta$ PWB ( $r=-0.01$ ). In addition, the strongest correlations were between affect variables. Post-HI, a negative correlation was observed between  $\Delta$ PWB and  $\Delta$ FAT ( $r=-0.85$ ). Post-LI, a positive correlation was observed between  $\Delta$ FAT and  $\Delta$ PD ( $r=0.75$ ).



**Figure 4.**  $\beta$ -endorphin levels for high and low intensities across groups. Values are mean  $\pm$  SE.

## DISCUSSION

A primary focus of this study was to determine the effect of fitness and activity levels on mood states with exercise. It was hypothesized that active individuals would report greater mood benefits than inactive individuals, regardless of intensity. This correlation was not observed, and no group differences were noted for any mood variable. A slight difference in Psychological Distress (PD) was evident

between groups (Figure 3), but this difference did not reach significance. The active group reported higher pre-exercise scores than the inactive, which then decreased post-exercise. Pre-exercise scores for PD were generally low across groups and, therefore, did not have room to improve significantly, especially in the inactive group. As a result, a significant correlation between activity level and decreases in negative mood states post-exercise cannot be established.

The lack of fitness effect on mood changes with exercise observed in this study contrasts with the literature<sup>[5,27,29,35,36,51]</sup>. The majority of these studies used surveys other than the SEES to measure mood, including the Profile of Mood States (POMS)<sup>[39]</sup>, Exercise-Induced Feeling Inventory (EFI)<sup>[20]</sup>, and the State-Trait Anxiety Inventory (STAI)<sup>[47]</sup>. The various inventories measure different affect and mood variables, which could explain the lack of difference between groups in the present study. In addition, duration of exercise was lower compared to duration in past studies<sup>[5,35,36]</sup>. Lochbaum et al.<sup>[35,36]</sup> used a 30-minute treadmill protocol and reported greater positive affect in active university students compared to inactive students. The active individuals in this study reported typical exercise bouts lasting 45-180 minutes in length. The 20-minute bout used in this study was significantly shorter than what they were accustomed to, and therefore may not have been adequate to elicit a significant mood response.

Mode of exercise also could have confounded results. Hoffman<sup>[29]</sup> found greater mood benefits following a treadmill test in ultra marathon runners compared to non-exercisers and regular moderate exercisers. These runners were accustomed to long bouts of running, whether on a treadmill, track, or sidewalk.

Most subjects in this study were not accustomed to treadmill running, or running in general. Other preferred activities were reported in the Physical Activity Questionnaire, including resistance training, swimming, basketball, racquetball, and dance. Including treadmill running in the participant selection criteria would have narrowed the subject pool and made recruiting difficult. It was, therefore, excluded from selection criteria in order to facilitate timely recruitment of participants. The novel exercise mode of treadmill running may have blunted any potential significant mood response in the active individuals compared to the inactive individuals.

There are studies that also found no evidence of a fitness effect on mood<sup>[8,9,13]</sup>. Blanchard et al.<sup>[8]</sup> assessed fit and unfit females in their mid-20s and found no differences in positive well-being between fitness levels, as measured by the SEES. The present study also found no significant difference in positive well-being response to exercise in active or inactive individuals. Daley and Welch<sup>[13]</sup> also tested university age subjects using a protocol similar to this study (20-minutes of treadmill exercise) that resulted in no difference between groups on any factor of the SEES. The studies that report comparable findings to those of the present study used similar subject groups, mood inventory, and/or duration and mode of exercise. The lack of effect of fitness level on mood could, therefore, be attributed to age and/or protocol of exercise. University age students are generally active as a result of walking or biking to class. Those that were placed in the inactive group were not completely sedentary, but rather engaged in irregular activity patterns. While a distinction between activity levels of the two groups was established, the gap may not have been large enough to elicit different mood responses. Future studies

should compare individuals with a longer history of inactivity to those that remain consistently active throughout their life. Due to the lack of a group difference, the rest of this discussion analyzes results collapsed across groups.

A second hypothesis examined by this study proposed that inactive individuals would receive greater mood benefits from LI exercise compared to HI exercise. Improved mood, specifically an increase in Positive Well-Being (PWB) and a decrease in Fatigue (FAT) on the SEES<sup>[38]</sup>, was observed for both groups from pre- to post-LI exercise but not HI exercise. These findings support those of previous studies<sup>[2,30,36,37,43,48]</sup>. The intensity by time interaction found for PWB was driven by an intensity effect ( $p=0.01$ ), as seen in Figure 1. A significant increase in PWB was reported following the LI bouts, while a slight decrease was reported following the HI bouts. McAuley et al.<sup>[37]</sup> also reported that PWB increased after light exercise and decreased after maximal. The LI level of exercise proved sufficient to increase feelings of strength and accomplishment without causing fatigue or distress to the body.

Decreases in FAT occurred post-LI exercise while increases in FAT occurred post-HI exercise (see Figure 2). Steptoe and Cox<sup>[48]</sup> reported the same phenomenon. Blood flow change with exercise is a possible physiological explanation for changes in FAT. The increased blood flow that occurs in response to exercise increases distribution of oxygen and nutrients throughout the body, leaving the individual energized after the LI exercise bout. If intensity is too high, however, all fuel resources are depleted, leaving the individual feeling tired and weak. The subjects of this study worked at an average of 83% of their respective  $VO_{2max}$ , or about 5%

above their VT, during the HI bouts. This level of exercise appears to be too high to enhance positive mood through decreased fatigue. Subjects averaged 66% of  $VO_2\text{max}$ , or 10% below VT, during the LI bouts, which proved sufficient for decreases in fatigue and increases in positive well-being. PD was the only mood variable not effected by intensity of exercise.

The final hypothesis proposed that higher  $\beta$ -E levels would correspond to greater increases in positive affect. This hypothesis was not supported.  $\beta$ -E levels were higher post-HI than post-LI in 83% of participants (Figure 4). In contrast, greater increases in PWB were observed following the LI condition compared to the HI condition. The findings of this study, which indicate that increases in mood are not correlated with higher  $\beta$ -E levels, differ from a link between the two variables reported in previous studies<sup>[10,14]</sup>. The higher  $\beta$ -E levels post-HI compared to post-LI suggest a greater increase from resting levels in the HI condition, but this increase may not have been sufficient to affect mood. It's possible a longer duration than 20-minutes of exercise is needed for a greater increase in  $\beta$ -E levels to subsequently affect mood. Daniel et al.<sup>[14]</sup> used a 75-minute high intensity aerobics class and Boeker et al.<sup>[10]</sup> measured  $\beta$ -E levels following a 2 hour run. Both studies reported a correlation between  $\beta$ -E levels and overall positive mood shift. It would also be beneficial to measure  $\beta$ -E before and after exercise in order for exact changes to be observed and compared to changes in affect.

Previous studies in the literature report higher levels of  $\beta$ -E release with greater exercise intensities, as observed in this study<sup>[22,23]</sup>. Goldfarb et al.<sup>[22]</sup> observed increases in  $\beta$ -E levels following exercise at 70% and 80%  $VO_2\text{max}$ , but

not at 60%  $VO_2$ max. The study established that an intensity of at least 70%  $VO_2$ max is necessary for significant increases in  $\beta$ -E levels. Subjects in the present study did not reach that level of intensity during the LI bout, explaining the lower  $\beta$ -E levels following LI exercise compared to HI exercise.

Intrinsic and psychological factors, not  $\beta$ -E levels, explain positive mood shifts following LI exercise. For most of these subjects, treadmill running is not the preferred or normal mode of exercise. Completing the LI bout increased mood through feelings of mastery and improved well-being. The subjects successfully ran the entire 20-minute period without significant negative physical effects, such as joint pain, muscle fatigue, or difficulty breathing. As a result, they felt accomplished at performing an unfamiliar activity. The HI exercise bouts decreased mood because the physical strain of the exercise was greater than the  $\beta$ -E response. Depletion of energy, aching muscles, and difficulty breathing left the subjects feeling weak and uncomfortable. The  $\beta$ -E response was not great enough to overcome these negative by-products of HI exercise.

### **Practical Implications**

The “feelings of enjoyment and well-being” that increase motivation for exercise, as described by Dishman et al.<sup>[15]</sup>, can be achieved through low intensity exercise. Activity at approximately 10% of  $VO_2$ max below VT or 65% of  $VO_2$ max is sufficient for improvements in mood. The findings of this study are especially salient for individuals just starting an exercise program. Beginners may be intimidated by exercise due to past experiences and/or current health status. Others are eager to start exercising, but begin at a high intensity that eventually discourages them from

continuing due to discomfort and lack of enjoyment. Low intensity exercise is ideal for beginners because it is less intimidating than high intensity exercise and is proven sufficient for psychological benefits. These benefits then have the potential to increase adherence.

### **Future Directions**

Future studies should establish a greater activity difference between groups, such as at least a year of sedentary behavior for inactive individuals and at least a year of regular vigorous exercise for active individuals. A larger separation between activity levels may elicit greater differences in mood disturbance. Exercise duration of at least 30 minutes could potentially cause a greater  $\beta$ -E response, and  $\beta$ -E should be measured pre- and post-exercise. In addition, this study, and many others, used a laboratory setting for collection of data. While findings may be significant, observing mood changes following exercise in a natural setting would provide valuable information. Allowing subjects to choose their activity, versus the experimenter dictating the exercise mode, could also vary the mood response. Studies featuring a large difference in activity level between groups, measurements of  $\beta$ -E before and after exercise of 30 minutes, and a mode chosen by the participants and performed in a natural setting would be a beneficial addition to the current literature regarding the affect of activity level on mood.

## REFERENCES

1. Acevedo EO, Kraemer RR, Haltom RW, et al. Perceptual responses proximal to the onset of blood lactate accumulation. *J Sports Med Phys Fitness*. 2003; 43: 267-73.
2. Acevedo EO, Kraemer RR, Kamimori GH, et al. Stress hormones, effort sense, and perceptions of stress during incremental exercise: an exploratory investigation. *J Strength Cond Res*. 2007; 21: 283-8.
3. American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription (7<sup>th</sup> ed.). Philadelphia (PA): Lippincott Williams & Wilkins, 2006.
4. Angelopoulos TJ. Beta-endorphin immunoreactivity during high-intensity exercise with and without opiate blockade. *Euro J Appl Physiol*. 2001; 86: 92-96.
5. Bixby WR, Lochbaum MR. Affect responses to acute bouts of aerobic exercise in fit and unfit participants: an examination of opponent-process theory. *J Sport Behav*. 2006; 29: 111-25.
6. Bixby WR, Spalding TW, Hatfield BD. Temporal dynamics and dimensional specificity of the affective response to exercise of varying intensity: differing pathways to a common outcome. *J Sport Exerc Psychol*. 2001; 23: 171-90.
7. Blanchard CM, Rodgers WM, Courneya KS, et al. Moderators of the exercise/feeling-state relationship: the influence of self-efficacy, baseline, and in-task feeling states at moderate- and high-intensity exercise. *J Appl Soc Psychol*. 2002; 32: 1379-95.
8. Blanchard CM, Rodgers WM, Spence JC, et al. Feeling state responses to acute exercise of high and low intensity. *J Sci Med Sport*. 2001; 4: 30-8.
9. Blanchard CM, Rodgers WM, Wilson PM, et al. Does equating total volume of work between two different exercise conditions matter when examining exercise-induced feeling states? *Res Q Exer Sport*. 2004; 75: 209-15.
10. Boecker H, Sprenger T, Spilker ME, et al. The runner's high: opioidergic mechanisms in the human brain. *Cerebral Cortex*. 2008; 18: 2523-31.
11. Cox RH, Thomas TR, Hinton PS, et al. Effects of acute 60 and 80%  $\text{VO}_{2\text{max}}$  bouts of aerobic exercise on state anxiety of women of different age groups across time. *Res Q Exer Sport*. 2004; 75: 165-75.
12. Cox RH, Thomas TR, Hinton PS, et al. Effects of acute bouts of aerobic exercise of varied intensity on subjective mood experiences in women of different age groups across time. *J Sport Behav*. 2006; 29: 40-59.
13. Daley AJ, Welch A. Subjective exercise experiences during and after high and low intensity exercise in active and inactive adult females. *J Sports Med Phys Fitness*. 2003; 43: 220-2.
14. Daniel M, Martin AD, Carter J. Opiate receptor blockade by naltrexone and mood state after acute physical activity. *Br J Sp Med*. 1992; 26: 111-15.
15. Dishman RK, Sallis JF, Orenstein DR. The determinants of physical activity and exercise. *Public Health Rep*. 1985; 100: 158-71.
16. Dunn EC, McAuley E. Affective responses to exercise bouts of varying intensities. *J Soc Behav Pers*. 2000; 15: 201-14.

17. Ekkekakis P, Hall EE, Petruzzello SJ. Practical markers of the transition from aerobic to anaerobic metabolism during exercise: rationale and a case for affect-based exercise prescription. *Prev Med.* 2004; 38: 149-59.
18. Ekkekakis P, Hall EE, Petruzzello SJ. The relationship between exercise intensity and affective responses demystified: to crack the forty-year-old nut, replace the forty-year-old nutcracker! *Ann Behav Med.* 2008; 35: 136-49.
19. Ekkekakis P, Petruzzello SJ. Acute aerobic exercise and affect: current status, problems, and prospects regarding dose-response. *Sports Med.* 1999; 28: 337-74.
20. Gauvin, L., Rejeski, W.J. The Exercise-induced Feeling Inventory: development and initial validation. *J Sport Exerc Psychol.* 1993; 15: 403-23.
21. Gauvin L, Rejeski WJ, Norris JL. A naturalistic study of the impact of acute physical activity on feeling states and affect in women. *Health Psychol.* 1996; 15: 391-97.
22. Goldfarb AH, Hatfield BD, Armstrong D, Potts J. Plasma beta-endorphin concentration: response to intensity and duration of exercise. *Med Sci Sports Exerc.* 1990; 22: 241-44.
23. Goldfarb AH, Hatfield BD, Potts J, Armstrong D. Beta-endorphin time course response to intensity of exercise: effect of training status. *Int J Sports Med.* 1991; 12: 264-8.
24. Grisel JE, Bartels JL, Allen SA, Turgeon VL. Influence of beta-endorphin on anxious behavior in mice: interaction with EtOH. *Psychopharm.* 2008; 200: 105-15.
25. Hall EE, Ekkekakis P, Petruzzello SJ. The affective beneficence of vigorous exercise revisited. *Br J Health Psychol.* 2002; 7: 47-66.
26. Hall EE, Folger SE, Miller PC, et al. Affective responses to a graded exercise test on a recumbent bicycle: when do I start to feel bad [abstract]? *Med Sci Sports Exerc.* 2004; 36: S166.
27. Hallgren MA, Moss ND, Gustin P. Regular exercise participation mediates the affective response to acute bouts of physical activity. *J Sports Sci Med.* 2010; 9: 629-37.
28. Hardy, C.J., Rejeski, W.J. Now what, but how one feels: the measurement of affect during exercise. *J Sport Exerc Psychol.* 1989; 11: 304-17.
29. Hoffman MD, Hoffman DR. Exercisers achieve greater acute exercise-induced mood enhancement than nonexercisers. *Arch Phys Med Rehab.* 2008; 89: 358-63.
30. Katula JA, Blissmer BJ, McAuley E. Exercise intensity and self-efficacy effects on anxiety reduction in healthy, older adults. *J Behav Med.* 1999; 22: 233-47.
31. Kennedy MM, Newton M. Effect of exercise intensity on mood in step aerobics. *J Sports Med Phys Fitness.* 1997; 37: 200-4.
32. Kilpatrick M, Jarreau D, Bartholomew J, et al. Comparing exercise bouts of different intensities and durations on post-exercise mood [abstract]. *Med Sci Sports Exerc.* 2004; 36: S286-7.
33. Kilpatrick MW, Kraemer RR, Bartholomew JB, et al. Affective responses to exercise are dependent on intensity rather than total work. *Med Sci Sports Exerc.* 2007; 39: 1417-22.

34. Kwan BM, Bryan A. In-task and post-task affective response to exercise: translating exercise intentions into behaviour. *Br J Health Psychol.* 2010; 15: 115-31.
35. Lochbaum MR. Viability of resting electroencephalograph asymmetry as a predictor of exercise-induced affect: a lack of consistent support. *J Sport Behav.* 2006; 29: 315-36.
36. Lochbaum MR, Karoly P, Landers DM. Affect responses to acute bouts of aerobic exercise: a test of opponent-process theory. *J Sport Behav.* 2004; 27: 330-48.
37. McAuley E, Blissmer B, Katula J, et al. Exercise environment, self-efficacy, and affective responses to acute exercise in older adults. *Psychol Health.* 2000; 15: 341-55.
38. McAuley, E., Corneya, K.S. The Subjective Exercise Experiences Scale (SEES): development and preliminary validation. *J Sport Exerc Psychol.* 1994; 16: 163-77.
39. McNair, D.M., Lorr, M. and Droppleman, L.F. (1971). *Manual for the Profile of Mood States.* San Diego, CA: Educational and Industrial Testing Services.
40. Oweis P, Spinks W. Biopsychological, affective and cognitive responses to acute physical activity. *J Sports Med Phys Fitness.* 2001; 41: 528-38.
41. Parfitt G, Rose EA, Burgess WM. The psychological and physiological responses of sedentary individuals to prescribed and preferred intensity exercise. *Br J Health Psychol.* 2006; 11: 39-53.
42. Rokka S, Mavridis G, Kouli O. The impact of exercise intensity on mood state of participants in dance aerobics programs. *Studies in Physical Culture and Tourism.* 2010; 17: 241-5.
43. Rose EA, Parfitt G. A quantitative analysis and qualitative explanation of the individual differences in affective responses to prescribed and self-selected exercise intensities. *J Sports Exerc Psychol.* 2007; 29: 281-309.
44. Schneider M, Dunn A, Cooper D. Affect, exercise, and physical activity among healthy adolescents. *J Sport Exerc Psychol.* 2009; 31: 706-23.
45. Sheppard KE, Parfitt G. Patterning of physiological and affective responses during a graded exercise test in sedentary men and boys. *J Exerc Sci Fitness.* 2008; 6: 121-9.
46. Smith JC, O'Connor PJ, Crabbie JB, et al. Emotional responsiveness after low- and moderate-intensity exercise and seated rest. *Med Sci Sports Exerc.* 2002; 34: 1158-67.
47. Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manual for the State-Trait Anxiety Inventory.* Palo Alto, CA: Consulting Psychologists Press.
48. Steptoe A, Cox S. Acute effects of aerobic exercise on mood. *Health Psychol.* 1988; 7: 329-40.
49. Stern, R.A., Arruda, J.E., Hooper, C.R., Wolfner, G. Visual analog mood scales to measure internal mood state in neurologically impaired patients: description and initial validity evidence. *Aphasiology.* 1997; 11: 59-71.
50. Thayer, R.E. *The biopsychology of mood and arousal.* New York: Oxford University Press, 1989.

51. Tieman JG, Peacock LJ, Cureton KJ, et al. The influence of exercise intensity and physical activity history on state anxiety after exercise. *Int J Sport Psychol.* 2002; 33:155-66.
52. Welch AS, Hulley A, Ferguson C, et al. Affective responses of inactive women to a maximal incremental exercise test: a test of the dual-mode model. *Psychol Sport Exerc.* 2007; 8: 401-23.

## ABSTRACT

A large percentage of the US population is physically inactive, increasing the risk of cardiovascular disease. Mood states associated with exercise are likely to influence future exercise adoption and adherence and merit further investigation. The present study examined how an individual's physical activity level and the intensity of acute bouts of exercise affect mood pre- to post-exercise and whether these changes correspond to  $\beta$ -endorphin levels.

Participants were 12 college students (4 male, 8 female) divided into active and inactive groups. Each participant completed a 20-minute bout of treadmill exercise at low intensity (10%  $VO_2$ max below VT) and high intensity (5%  $VO_2$ max above VT). Before and after each bout, subjects completed the Subjective Exercise Experience Scale. A blood draw was also done post-exercise to determine plasma  $\beta$ -endorphin levels.

No difference in affect response was observed between groups. Low intensity exercise elicited a significant increase in positive well-being, as well as smaller decreases in fatigue and psychological distress.  $\beta$ -endorphin levels were higher following the high intensity bout compared to the low intensity bout. No significant relationship was observed between  $\beta$ -endorphin levels and changes in mood.

The findings of this study suggest that low intensity exercise is sufficient for improvements in mood states regardless of fitness level, and that these improvements are not correlated with  $\beta$ -endorphin levels. Encouraging individuals to begin a low intensity exercise program could potentially decrease the prevalence of physical inactivity due to the associated mood improvements.