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Psychological and physiological changes associated with a period of increased training

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PSYCHOLOGICAL AND PHYSIOLOGICAL CHANGES

ASSOCIATED WITH A PERIOD OF

INCREASED TRAINING

by

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The purpose of this exploratory study was to determine if psychological and physiological responses during a period of normal baseline training are similar to psychological and physiological responses during a period of increased training conducted at the same intensity as the baseline training.

Eleven moderately trained male and female endurance runners participated in the study. During the first week of training, baseline training week, runners ran their average weekly distance over five consecutive days. During the second week of training, increased training week, runners ran 1.5 times their average weekly distance, over five consecutive days. Runs were conducted between 70 - 75% maximal aerobic capacity each week. Psychological measures were collected prior to, during, and after each run and physiological measures were collected twice each run.

A series of repeated measures ANOVAs were conducted to examine weekly, temporal, and daily changes in psychological and physiological responses. The results of the weekly analyses revealed that mood became less negative and more positive during the increased

training week as compared to the baseline training week, and that the runners were not physiologically stressed any differently by the increased training. Temporal analyses revealed that mood became more positive and less negative over time during runs and daily analyses revealed that mood tended to become less negative over successive days of training each week. Results indicate that five days of increased training does not result in mood disturbance or physiological stress compared to baseline training conducted at the same intensity.

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CHAPTER I

INTRODUCTION

Understanding what one is feeling, as well as how one is feeling during exercise may allow further insight into the relationship between psychological responses (e.g., thoughts, feelings, affect) and physiological responses to exercise (e.g., heart rate, ventilation, oxygen consumption). Furthermore, how one is feeling (e.g., angry, happy) during exercise may be associated with what one is feeling during exercise (e.g., perception of effort). How and what an individual is feeling while resting or during exercise is important because psychogenic factors such as thoughts, feelings, and sensations can influence resting and exercise metabolism (Morgan, 1985b). Conversely, exercise can influence psychological states, as chronic exercise can decrease depression and enhance self-esteem; and acute exercise may reduce anxiety and enhance mood (Boutcher & Landers, 1988; Morgan, 1985a; Roth, 1989; Steptoe & Cox, 1988). Thus, the study of mood and affect within sport and exercise psychology may have implications for mental health and well-being.

Before examining associations with exercise, terms such as mood, affect, and emotion, should be defined. These words are often used interchangeably, and there is definitional overlap among the terms. Although there is no consensual definition of emotion, Young (1973) suggested three components of emotions: subjective experience, physiological changes within the autonomic nervous system, and observable behavior. Deci (1980) proposed the following general definition of emotion, which incorporates the three fundamental components:

> An emotion is a reaction to a stimulus event (either actual or imagined). It involves changes in the viscera and musculature of the person, is experienced subjectively in characteristic ways, is expressed through such means as facial changes and action tendencies, and may mediate and energize subsequent behaviors. (p. 85)

Affect and emotion can be considered synonymous (Ketai, 1975; Thayer, 1989; Vallerand, 1983), but mood and affect are conceptually distinct experiences that can be distinguished based upon duration and intensity. Affect connotes immediate and intense psychological experiences whereas mood refers to more enduring, and usually less intense emotional states. Although affect, emotion, and mood are used interchangeably in psychological literature; in this paper, affect and emotion will refer to immediate and intense psychological states and mood will be used to denote less intense, enduring psychological states.

Although there are approximately 200 to 5000 emotion words (Averill, 1975; Wallace & Carson, 1973), many of these words are interrelated rather than independent. The interrelations among various emotions has implications for theoretical conceptions, structure, and measurement of mood and affect.

Presently, the relationships and dimensions along which emotions vary are best conceptualized within a circumplex structural model (Russell, 1980, 1989; Schlosberg, 1952). The circumplex model proposed by Russell (1980, 1989) places affect within a two-dimensional bipolar space. As displayed in Figure 1, the horizontal dimension varies along pleasure - misery (pleasure dimension) and the vertical axis varies along sleepiness - arousal (arousal dimension). According to Schlosberg (1952) and Russell (1980), any affect word can be defined as some combination of pleasure and arousal. Thus, emotions are interrelated and vary along pleasure and arousal dimensions. As will be discussed later, this conceptualization of emotions has implications for the measurement of mood and affect within sport and exercise psychology.

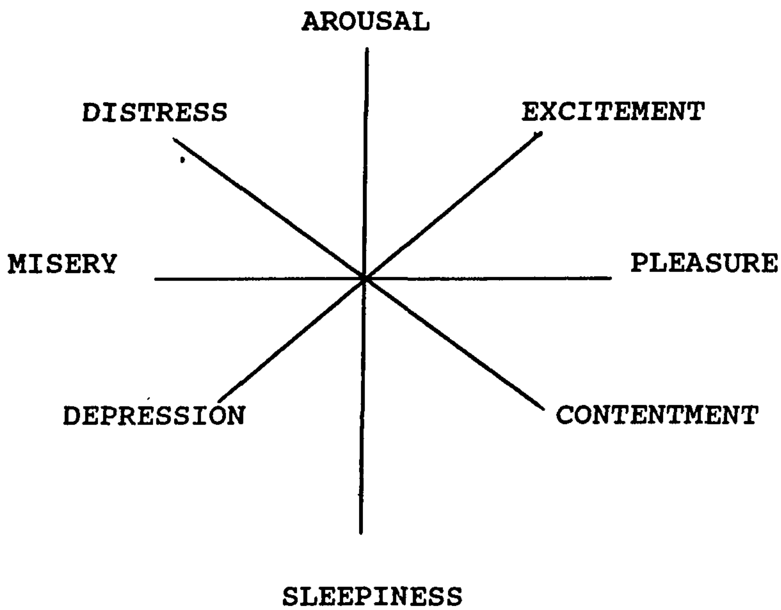

FIGURE 1. Affects Arranged in a Circular Order

Numerous studies have documented psychological benefits of aerobic exercise, including decreased depression, decreased anxiety, and improved mood (Morgan, 1985a; North, McCullagh, & Vu Tran, 1990; Petruzzello, Landers, Hatfield, Kubitz & Salazar, 1991; Roth, 1989; Roth & Holmes, 1987). An understanding of the effects of exercise on specific emotional states such as anxiety or depression is important, especially if exercise is therapeutic or anxiolytic. However, in order to gain a better understanding of associations between emotional states and exercise, a range of emotional experiences and physical activities need to be examined. Furthermore, attempts should be made to examine mood and affect within theoretical and conceptual frameworks to understand and elucidate associations among psychological, physiological, and behavioral components of emotional experiences. Thus, rather than reviewing studies that have examined effects of exercise on specific emotional states such as anxiety or depression, studies examining associations between mood, affect and exercise from a more general and global perspective will be reviewed.

In terms of exercise, either acute or chronic effects of exercise on mood and affect can be examined. Typically, mood and affective changes following a single bout of exercise are examined, because controlled conditions permit easier assessments (Steptoe & Cox, 1988). Examining affective responses to single bouts of exercise, Steptoe and Cox (1988) found differential effects of high-intensity (50 rpm, 100 W) and low-intensity (50 rpm, 25 W) aerobic exercise on mood. Participants completed four 8-min trials on a cycle ergometer. One high-intensity and one low-intensity trial were completed while listening to music. The other high and low-intensity trials were completed while listening to a metronome used to set the cadence. Steptoe and Cox (1988) found that tension/anxiety and fatigue subscales of the Profile of Mood States (POMS) (McNair, Lorr, & Droppleman, 1971) increased after high-intensity exercise in fit and unfit female exercisers. Low-intensity exercise increased vigor and decreased fatigue. Music did not influence moods, but ratings of perceived exertion were lower during the music trials.

Several other studies have also examined acute effects of exercise on mood. Markoff, Ryan, and Young (1982) found that a 1-hr run, completed at participants' self-selected training pace, decreased tension/anxiety and anger/hostility subscales of the POMS in trained male and female runners. Farrell, Gustafson, Morgan, and Pert (1987) found that prolonged exercise (80 min at 40%, 80 min at 60%, 40 min at 80% $\dot{V}O_2max$) was associated with decreased tension/anxiety after 60% and 80% $\dot{V}O_2max$ for trained runners. Kraemer, Dzewaltowski, Blair, Rinehardt, and Castracane (1990) examined mood alterations in response to treadmill running in trained and untrained male and female runners. Kraemer et al. (1990) found that a 30-min treadmill run at 80% max HR resulted in decreased tension, depression, anger, and confusion subscales of the POMS, and improved composite mood, a measure indicating less negative mood. Petruzzello et al. (1991) found that aerobic exercise conducted at an intensity of at least 70% $\dot{V}O_2max$ or age adjusted HRmax was effective in improving mood. Additionally, exercise was better than a placebo control group (e.g., relaxation group, quiet rest, yoga) for improving mood. Thus, the results of the studies reviewed lead to the conclusion that acute single bouts of aerobic exercise of sufficient intensity and duration are associated with improved mood states.

Hypotheses based upon psychological distraction (Bahrke & Morgan, 1978), monoamine metabolism (Greist, Klein, Eischens, Faris, Gurman, & Morgan, 1979; Ransford, 1982), opiod release (Farrell, Gates, Maksud, & Morgan, 1982; Pargman & Baker, 1980), thermogenic control (deVries, Beckman, Huber, & Dieckmeir, 1968; Raglin & Morgan, 1985), and psychological expectancies have been proposed to explain mood and affective changes associated with acute and chronic exercise. For example, the distraction hypothesis (Bahrke & Morgan, 1978) proposes that distraction from stressful stimuli, not necessarily exercise itself, leads to improved affect. Thus, exercise serves as "time-out" from stressful stimuli. The endorphin/opiod hypothesis proposes that increases in beta-endorphin/beta-lipotropin concentrations alter psychological states (e.g., improved affect). According to this hypothesis, exercise which increases beta-endorphin and beta-lipotropin secretion may be associated with improved affect (Farrell, Gates, Maksud, & Morgan, 1982). Although none of above hypotheses has unequivocal support, each remains as a possible explanation for improved emotional states associated with acute and chronic exercise (Morgan, 1985a; Petruzzello, 1991). It is not the intent of this exploratory study to examine the viability of proposed hypotheses explaining affective change associated with exercise, but rather to alter exercise (i.e., increase training) and compare psychological and physiological responses during a baseline and increased training period.

Several studies have examined emotional responses to chronic or successive bouts of exercise. Morgan, Brown, Raglin, O'Connor, and Ellickson (1987) reported results of research conducted over a 10-year period during which they monitored mood states (POMS) of competitive swimmers during 2-4 week intervals throughout their season. Morgan and colleagues (1987) found that mood state disturbances increased (e.g., increased depression, anger, fatigue, decreased vigor) as training loads increased and mood state disturbances decreased with reductions in training loads. Morgan et al. (1987) suggested that monitoring mood states could serve as a method of preventing staleness.

Morgan, Costill, Flynn, Raglin, and O'Connor (1988) monitored mood disturbances in swimmers during a 10-day period of increased training. Morgan et al. (1988) found that depression, anger, and fatigue increased over the period, and plateaued at day 4. Additionally, the composite mood score (POMS) increased, indicating more negative mood, within the first five days and then remained steady throughout the remaining five days of intensified training.

Morgan et al. (1988) examined psychological responses to successive days of intense training in competitive swimmers and Kirwan, Costill, Flynn, Mitchell, Fink, Neufer, and Houmard (1988) examined physiological responses in the same swimmers. Training was increased for 10 days by doubling training volume (i.e., distance), swimmers swam in the morning and evening during the intensified training period. Physiological responses were monitored on days 0, 5, and 11 of the training period. Results revealed that performance (maximal swim time and power output) was not affected by 10 days of intensified training, thus the swimmers were not considered overtrained. Resting heart rate and resting systolic blood pressure were unaffected by the intensified training. Resting plasma epinephrine and norepinephrine concentrations did not change as a result of the increased training load. Resting blood lactate concentrations were lower on days 5 and 11 than day 0. Pre-exercise serum cortisol and plasma creatine kinase (CK) concentrations were significantly elevated on days 5 and

11 compared to day 0. Kirwan et al. (1988) concluded that the elevation of physiological parameters (e.g., cortisol, CK) was a normal response to the stress of an increased training load. Because performance was not impaired the swimmers were not considered overtrained (performance decrements characterize the overtrained state). Increased cortisol levels may have indicated that the swimmers were stressed psychologically as well as physiologically as cortisol is associated with psychological stress.

Morgan et al. (1988) reported that increased training was associated with increased ratings of exercise intensity, muscle soreness, anger, depression, fatigue, global mood disturbance as assessed by the POMS, and a reduced sense of well-being. Three of the nine swimmers participating in the intensified training were not able to tolerate the increased training load and were classified as "responders" (physiologically distressed) on the basis of physiological responses (e.g., lower muscle glycogen concentration, swam at reduced speed); the others were classified as "nonresponders". Morgan and colleagues (1988) then classified swimmers as psychological responders and nonresponders. Psychologically, responders had elevated POMS mood scores (e.g., increased depression, anger, tension, fatigue). The physiological data was then used to predict psychological responders and Morgan et al.

(1988) found that physiological distress was highly related to psychological distress. The combined psychological and physiological data distinguished responders and nonresponders. Although this is an interesting finding, the three swimmers with low deltoid glycogen concentration had lower levels than the other swimmers prior to the increased training and lower carbohydrate consumption, thus their classification as responders to the increased training loads may not be entirely accurate.

As previously mentioned, in order to gain a better understanding of associations between mood, affect and exercise behavior, a range of physical activities should be examined. The studies reviewed in the following section examine physiological and psychological responses of runners rather than swimmers to periods of increased training and successive bouts of exercise.

Costill, Bowers, Branam, and Sparks (1971) examined physiological responses to three successive days of prolonged exercise (16.1 km at 80% $\dot{V}O_2max$) in moderately trained male runners ($\underline{M}$ $\dot{V}O_2max$ = 56.96 ml·kg·$^{-1}$min^{-1}). The successive days of prolonged training resulted in lower vastus lateralis glycogen concentration, lower blood lactate concentrations, and decreased respiratory exchange ratios, indicating greater reliance on free fatty acids (FFA) for energy production. Because dietary intake was not monitored or controlled in this study, Kirwan, Costill, Mitchell, Houmard, Flynn, Fink, and Beltz (1988) in a follow up study, examined physiological responses of runners to 5 days of intensified training while controlling carbohydrate intake. Ten highly trained runners ($\underline{M}$ $\dot{V}O_2max$ = 67.6 $ml\cdot kg\cdot^{-1}min^{-1}$) ran 1.5 times their average daily distance (appox. 20 $km\cdot day^{-1}$) for 5 days at approximately 80% $\dot{V}O_2max$. Participants consumed either a low carbohydrate diet or carbohydrate diet sufficient to meet their daily energy expenditure while completing the successive days of increased training. Kirwan et al. (1988) found that after 3 and 5 days of training, gastrocnemius glycogen concentration was lower for runners on low CHO diets and glycogen concentration was lower on day 5 for runners receiving adequate CHO diets. Running economy worsened (increased oxygen cost for a given workload) and ratings of perceived exertion increased for runners on the low CHO diet. The change in running economy reported was probably associated with increased use of FFA as a result of the low CHO diet. Thus, the increased oxygen consumption may represent a change in substrate metabolism and utilization rather than a change in economy. Running economy improved three days after intensified training stopped indicating that the runners probably replaced carbohydrate stores and were fatigued or metabolically stressed from the training rather than overtrained.

Morgan, Costill, Kirwan, Raglin, and O'Connor (1988) examined the psychological responses of these same runners to successive days of increased training. Morgan et al. (1988) found that subjective ratings of exercise intensity, sluggishness-heaviness, and muscle soreness increased over the five-day period. Additionally, POMS subscales and state anxiety (STAI) increased, suggesting psychological distress.

Williams, Krahenbuhl, and Morgan (1991) examined relationships between mood states and running economy in moderately trained male runners over a four-week period. Participants ran three 6-min sessions at 2.68, 3.13, and 3.58 $m \cdot sec^{-1}$ five days a week for four weeks. The POMS was completed prior to running on the fifth day of each week. Results revealed a positive within-subject correlation between running economy and total mood disturbance (r = .88) with more economical weeks associated with more positive mental health profiles.

The results of Williams, Krahenbuhl, and Morgan (1991), and a series of studies by Morgan and colleagues with swimmers and runners suggest a strong association between psychological and physiological responses to exercise. Furthermore, psychological and physiological responses to an intensified training period occurred relatively soon, typically within 5 days. This finding suggests that extended intensified training periods may be associated with greater mood disturbances and performance decrements.

In addition to examining mood and affective changes across training periods, it is also important to examine mood and affect during exercise. Affect assessed while one is exercising may have implications for mental health (Hardy & Rejeski, 1989), and performance (Caruso, Morgan & Crews, 1991). Hardy and Rejeski (1989) developed an instrument for the measurement of positive and negative affect during exercise, the Feeling Scale (FS). Hardy and Rejeski (1989) demonstrated that the FS and ratings of perceived exertion (RPE) were moderately related across varying workloads (30%, 60%, 90% $\dot{V}O_2max$). Associations between RPE and FS increased as demands of the workload increased. Increases in workload resulted in higher RPE's, more negative affect, and enhanced physiological responses (e.g., increased heart rate, increased ventilation, increased oxygen consumption). Ratings of affect after exercise, as well as assessing recall of affect during exercise, revealed that affect after exercise and during exercise were related during the easy and hard workloads but not during the moderate workload

(60% $\dot{V}O_2max$). Thus far, the Feeling Scale has not been widely used in sport and exercise psychology. Therefore, there is a need for further use of the Feeling Scale to determine validity, as well as associations between affect and physiological and psychophysiological responses during exercise.

Our knowledge of mood and affective changes associated with acute and chronic exercise has been limited due to over reliance on one primary assessment instrument, the Profile of Mood States (POMS). The POMS was originally developed as a measure of mood states and mood changes in psychiatric outpatients, and thus its generalizability to normal populations may be limited. The POMS consists of six mood states: tension/anxiety, depression/dejection, anger/hostility, vigor/activity, fatigue/inertia, and confusion/bewilderment. A major limitation of the POMS is that there is only one positive mood state (i.e., vigor) and the remaining mood states are negative. Although these mood states may be relevant to and associated with exercise behavior, we do not clearly know the effects of exercise, either acute or chronic, on positive mood and affect or the pleasure and arousal dimensions of affect. Another difficulty with the POMS is that the inventory is rather cumbersome (65 items) and requires several minutes to complete, thus preventing the assessment of affect during exercise. Additionally, fatigue and vigor subscales may be influenced by physiological changes associated with physical activity rather than subjective psychological changes in mood, and therefore, exercise may distort responses to the POMS. Thus, knowledge of mood and affective changes associated with exercise is limited due to overreliance on one instrument (i.e., POMS) to assess mood.

Although several inventories exist for measuring mood and affect, not all inventories are appropriate for sport and exercise settings. Shortcomings of inventories limiting their use in sport and exercise settings include: validation with clinical populations, lack of a conceptual basis, time constraints, and failure to measure both positive and negative states. Social psychologists, Watson, Clark, and Tellegen (1988), developed an inventory for the assessment of mood and affect, the Positive and Negative Affect Schedule (PANAS). The inventory consists of a 10-item positive affect scale (attentive, proud, determined, strong, active, interested, alert, excited, enthusiastic, inspired) and 10-item negative affect scale (distressed, upset, hostile, irritable, scared, afraid, ashamed, guilty, nervous, jittery). The inventory can be used as a measure of affect or mood and adequate reliability and validity has been reported, based upon an undergraduate sample, for the PANAS (e.g., internal consistency 0.86 to 0.90 for positive affect and 0.84 to 0.87 for negative affect) (Watson, Clark, & Tellegen, 1988). Watson et al. (1988) also reported similar reliabilities with an adult nonstudent sample, however, they acknowledged that further data are needed to verify this information.

Thus, the PANAS may be a useful instrument for assessing positive and negative mood and affect in sport and exercise settings due to its conceptual basis, validation with undergraduate and nonstudent adult samples, potential ease of administration (20 items), and ability to assess positive and negative dimensions of mood and affect.

Another inventory with potential applicability in sport and exercise settings is the Affect Grid developed by Russell, Weiss, and Mendelsohn (1989). The Affect Grid provides a quick means of assessing affect along dimensions of arousal-sleepiness and pleasure-displeasure. The Affect Grid is a 9 X 9 grid which requires respondents to place a single mark on the grid, this single mark then reflects an individual's affect along the dimensions of arousal-sleepiness and pleasure-displeasure.

Both the Affect Grid and PANAS are conceptually-based inventories with adequate reliability and validity, based upon undergraduate student and nonstudent adult samples. Advantages over the POMS include ease of administration, less time-consuming which potentially minimizes response bias, and assessment of both positive and negative dimensions of mood and affect. The Affect Grid has not been used in sport or exercise settings. The PANAS has been used to examine affective responses to moderate aerobic exercise (Ainsworth, Hardy, Depue & Leon, 1990). Physically inactive individuals participated in a walking program or flexibility program for 12 weeks, preceded by a 2-week baseline without exercise, and followed by a 2-week follow-up without exercise. Participants completed the PANAS in the morning and evening throughout the program. Results revealed that positive affect was higher in the evening and there was a trend for positive affect to increase with walking. The flexibility program had a moderating effect on negative affect, as negative affect decreased during the exercise program.

<u>Summary</u>

The studies reviewed indicate that physiological responses to periods of increased training occur relatively quickly. Success and performance improvements for participants in endurance events such as swimming, cycling, and running require progressive increments in the training load (e.g., increased intensity, increased frequency, increased duration). Although physiological responses to a period of increased training have been examined, psychological responses, specifically mood and affect, have not been closely examined. The effects of increased training on positive and negative or pleasure and arousal dimensions of mood and affect during exercise and across a period of increased training are not known. Additionally, relationships between physiological and psychological responses to increased training are not known. A further understanding of mood and affective changes associated with exercise and increased training may have implications for well-being and mental health.

Statement of Purpose

Previous research indicates an association between mood and affective states and physiological responses to exercise. Exercise (acute and chronic) has been shown to have both positive and negative influences on mood, but we do not clearly understand the effects of successive days of exercise or successive days of increased training on psychological responses. The purpose of the present study was to determine if psychological and physiological responses during a period of normal baseline training are similar to psychological and physiological responses during a period of increased training conducted at the same intensity as the baseline training. Specifically, mood, affect, perceptions of exertion, and physiological responses associated with physiological distress (i.e., heart rate, oxygen consumption, respiratory exchange ratios, ventilation) were examined during a period of normal baseline training and increased training.

Research Questions

Due to the exploratory nature of this study, the following questions will be examined rather than proposing specific hypotheses:

(1) Are psychological responses during a period of baseline training different from psychological responses during a period of increased training?

(2) Are physiological responses during a period of baseline training different from physiological responses during a period of increased training?

(3) Does mood change over successive days of baseline or increased training runs?

(4) Does mood/affect change during single sessions of baseline or increased training?

CHAPTER II

LITERATURE REVIEW

Introduction

This review will define and differentiate mood and affect, examine current theoretical conceptions of mood and affect, examine the structure of mood and affect, and discuss implications of the literature reviewed for the measurement of mood and affect. Because the study is examining psychological and physiological responses to increased training, physiological responses to increased training will also be examined. The intent of the review is to provide conceptual and structural frameworks of mood and affect so that associations between psychological and physiological responses to exercise can be better understood.

Defining and Differentiating Mood and Affect

Mood and affect are terms used to conceptualize emotional experiences. Although mood and affect may refer to distinct emotional states, consensual definitions and differentiations of the two concepts are lacking. Thus, one may wonder if it is necessary to distinguish between the two concepts. However, accepting that a further understanding of the effects of mood and affect on objective responses (e.g., physiological responses to exercise, behavior) is an important endeavor with potential implications for subsequent behavior, emotional responses, and physiological responses, it will be necessary to precisely describe and define emotional experiences.

Attempting to define and differentiate mood and affect, Ketai (1975) reviewed semantic considerations of mood, affect, emotion, and feeling. Drawing upon psychological, psychiatric, and dictionary conceptions and definitions of mood and affect, Ketai found semantic confusion within the literature. Concluding that mood and affect are not synonymous and that they refer to distinct conceptual and psychological phenomena, Ketai suggested a conceptual distinction between mood and affect is necessary. According to Ketai (1975) affect should be considered as an immediate emotional experience which may vary in sensations, displays and quality. Examples of affect include anger, joy, sadness, etc. Additionally, mood and affect are both felt and expressed, yet mood refers to a more sustained, less flexible, and less intense emotional state than affect. Thus, intensity and persistence over time are characteristics that differentiate mood and affect.

Interestingly, there has been a resurgence of interest in the study of mood and affect since the 1980's (Thayer, 1989). Tomkins (1981) stated that "the next decade or so belongs to affect", yet consensual definitions and measures of mood and affect are still lacking. Furthermore, mood and affect are not major topics or descriptors in the Psychological Abstracts. Mood and affect-related articles are under the descriptor "emotional states", yet Thayer (1989) reported that there were more than 1,000 published articles related to mood in the past ten years. Reviewing the mood literature and presenting current conceptions of the structure of mood, Thayer (1989) outlined common uses and differentiations among mood, affect, emotion, and feeling. As Ketai (1975) stated, these words are often used interchangeably and there is no consensus about the terms; thus, Thayer examined similarities and differences among the terms.

According to Thayer (1989), mood and emotion are related terms, with mood usually implying a longer duration of time than emotion. Another distinguishing characteristic is that antecedents of emotions can be identified whereas moods come and go and vary, lacking an indentifiable cause (Thayer, 1989). A futher distinction between mood and emotion is that emotion can be more variable and intense than mood. Mood may be difficult to identify, but emotion is easily identifiable and variable. Mood and emotions are similar in that they are both feeling states rather than thoughts (cognitions). There may be some contention with the last statement, as evaluation of mood and affect typically involves a cognitive response (e.g., self-report of mood or affect). The cognitive evaluative component of mood and affect has implications for the measurement of mood and affect, which will be examined in a subsequent section. Mood also differs from affect in that mood is sometimes inferred from subjective reports as well as behavior (e.g., posture, tone of voice). Mood has also been referred to as a disposition rather than a set of behaviors. However, even though a person in a particular mood may act a certain way, mood does not necessarily control behavior but may serve to influence behavior.

Based upon conceptual distinctions presented by Ketai (1975) and Thayer (1989) mood and affect can be distinguished based upon immediacy (duration) and intensity dimensions. Furthermore, affect and emotion are synonomous. Thus, distinguishing between affect and mood, affect refers to immediate and intense psychological responses and mood refers to less intense psychological responses or states persisting over a period of time.

Theories of Emotion

This section reviews theoretical conceptions of emotion. Current theories of emotion reflect one of four traditional views: evolutionary, associated with Charles Darwin; psychophysiological, associated with William James; neurological, associated with Walter Cannon; and psychodynamic, associated with Sigmund Freud. This review will not extensively examine contemporary attempts to develop theories based upon each of these traditional views; rather, this section provides a background and overview for current conceptions of the structure and dimensions of emotions which will be reviewed later.

Darwin's (1872) evolutionary approach emphasizes the survival value of expressed emotional behavior in animals and humans. According to Darwin, emotional expressions in animals and humans are adaptive and functional. Current evolutionary theories include Tomkins (1970), Izard (1972), and Plutchik (1962). Tomkins' (1962, 1970) posited eight basic positive and negative affects. The positive affects are: interest, surprise, and joy. The negative affects are: anguish, fear, shame, disgust, and rage. These are "innately patterned response" affects to certain stimuli expressed through facial responses and bodily reactions.

Furthermore, each basic affect has a specific "program" stored in a subcortical area of the brain (Tomkins, 1962). Thus, expression of the basic emotions has a genetic species-specific basis (Tomkins, 1962, 1970). Tomkins also distinguished between an affect system and a drive or motivational system in his theory. He viewed the affect system as more general than the drive system. Affects are stronger than drives and affective/emotional states lead to certain actions or behavior sooner than drive states and independent of drive states. For example, a person frightened by an attacking stranger will run regardless of whether or not he/she is hungry, thirsty, etc.

Izard (1972) a collaborator of Tomkins, extended Tomkins' theory. Izard stated that previous theories have placed too much emphasis on the role of autonomic nervous system feedback in the perception of emotions. Izard (1972) proposed that affects are primarily facial responses. Facial responses or patterns, emotions have a neurological basis in subcortical "programs" and are not learned responses (Izard, 1972). Izard (1972) proposed a list of basic, fundamental emotions. Among these are interest, joy, surprise, distress, anger, disgust, contempt, shame, and fear. Additionally, it is unlikely that these emotions occur independently or in isolation, but rather simultaneously with several emotions.

The last evolutionary theory that will be reviewed is Plutchik's (1962) theory of emotion. Plutchik (1962) identified problems that need to be examined in theories of emotion, including: intensity, persistence, purity, individual differences, and introspection. Plutchik posited that emotions must be considered from a broad, evolutionary perspective. Emotions have fundamental components that can be found in adults, children, and animals. Emotions are not simply related to conscious feeling states or introspections but must be inferred. According to Plutchik, emotions are not simply subjective experiences but should also be thought of as theoretical concepts. Plutchik (1962) formulated a list of primary emotions, including: incorporation (acceptance), rejection (disgust), destruction (anger), protection (fear), reproduction (joy), deprivation (sorrow), orientation (surprise), and exploration (expectation).

The evolutionary theories reviewed suggest that a core of emotions exists. Furthermore, these basic emotions are not species-specific. An immediate criticism of Tomkins' and Izard's theories, which emphasize facial expressions and responses, is that phylogenetically it becomes more difficult to distinguish facial expressions as one proceeds from humans to animals. Another criticism is the lack of a strong basis or rationale for the primary emotions in each of the theories. Plutchik's recognition of problems that need to be considered in theories of emotion are insightful and provided some basis for the distinction between mood and affect (e.g., intensity, persistence), though this was probably not a primary intention.

The psychophysiological approach, associated with William James (1890) is concerned with relationships between feelings and internal bodily or physiological changes. The James-Lange theory of emotion posits that an emotional-arousing stimulus produces physiological arousal, which is subsequently appraised as an emotion. Thus, according to James (1890) physiological arousal precedes the cognitive appraisal of an emotion. The issue of whether physiological arousal precedes cognitive appraisal of an emotion or cognitive appraisal leads to physiological arousal differs among psychophysiological theories of emotion (i.e., arousal, cognitive, behavioral).

Behavioral approaches are asssociated with Watson (1924), Tolman (1923), and Skinner (1938). Basically, behavioral approaches view emotions as responses that occur with some constancy and regularity to certain stimuli. Cognitive and arousal theories of emotion (psychophysiological) are concerned with perceptions and arousal states. Schacter and Singer's (1962), Mandler's (1975), and Lazarus's (1968) theories are cognitive theories of emotion.

According to Schacter and Singer (1962) physiological arousal occupies a central role in all emotional states. Physiological arousal is a precursor of an emotional state. An emotional state is dependent upon physiological arousal and a person's interpretation of the situation he or she is in. Schacter and Singer's theory is not free from criticism. Harris and Katkin (1975) reviewed literature examining the relationship between autonomic arousal and emotions and found that emotions can occur without evidence of arousal and arousal can occur independent of emotions. Although Schacter and Singer's (1962) theory and experiments have been criticized, their work did provide an impetus for future research and emphasized the importance of cognitive factors and social factors (e.g., person's interpretation of events and situations) in determining emotions.

Mandler (1975, 1984) also emphasized the role of physiological arousal in his theory of emotions. According to Mandler (1975), emotions and moods are combinations of "arousal and meaning analysis", meaning analysis is a cognitive appraisal or evaluation of a situation. Conscious awareness of emotions is the product of arousal and evaluative cognitions. In Mandler's view, autonomic system arousal is an activator of certain action patterns and a signal system for evaluating situations. Similar to Schacter and Singer's (1962) theory, Mandler emphasized the importance of physiological arousal and cognitions in perceptions of emotion. However, the criticism of Schacter and Singer's (1962) theory that arousal of the autonomic nervous system does not always play a central role in emotional states or emotional behavior is also applicable to Mandler's theory. It is also important to recognize that arousal of the autonomic nervous system is usually diffuse and general, and thus labeling a particular emotional state with a specific arousal pattern is probably not realistic or possible.

The final psychophysiological approach reviewed is that of Lazarus (1968). Lazarus (1968) viewed emotion as a coping response. According to Lazarus (1968), there is a sequence of events that are associated with an emotion. Emotions include three main components: subjective affect, physiological change related to mobilization for adaptive action, and action impulses. Additionally, the quality and intensity of a particular emotion is dependent on one's cognitive appraisal and reappraisal of a particular event. Lazarus (1968) noted that emotions are inferred from various types of evidence (e.g., facial expressions, self-report, physiological changes) and that no single measure can adequately describe any emotion. Thus, a multifaceted approach to the study of affect and emotion is warranted, as no single measure is an unambiguous index of emotion.

The remaining two traditional views of emotion, neurological and psychodynamic, have important ideas about emotions but there have been fewer theoretical developments from these approaches than from evolutionary and psychophysiological approaches. Walter Cannon's (1929) neurological approach to the study of emotion emphasized the relationship between emotional feelings or behaviors and particular brain structures and activities. The psychodynamic approach examines emotions that people are unaware of and the meaning of mixed emotions that people have. Today, Cannon's views would probably be considered within the realm of the psychophysiological approach. Both Cannon and James (1890) acknowledged that perception (cognition) is necessary in emotional states and that subjective reports are valid expressions of emotional feelings. However, Cannon and James (1890) differed in that James found the source of emotional feelings in the viscera and Cannon in the thalamus.

Traditional views of emotions, evolutionary, psychophysiological, neurological, and psychodynamic provided the basis for current theoretical conceptions of emotions and affect. In general, these approaches suggest that a single unambiguous measure of emotion or affect does not exist. The study of emotional behavior should encompass a mulifaceted multimethod approach assessing behavioral, cognitive, and physiological components of emotional behavior.

Structure and Dimensions of Mood and Affect

Although theories often explain phenomena and guide research directions, guiding theoretical frameworks are lacking for the study of mood and affect. The theories reviewed have revealed that there are physiological, cognitive, and behavioral components to emotions. A multifaceted conceptualization of emotions has implications for the measurement and assessment of affect and mood. However, methodologies and assessment instruments are sometimes developed not from a particular theory of emotion, but rather from a structural or dimensional model of emotions. Issues that need to be examined concerning the structure of emotions include the polarity of emotions (e.g., monopolar or bipolar), and dimensions or underlying structure of emotions. After discussing issues related to the structure and dimensions of emotions, specific instruments used to assess mood and affect will be examined.

Polarity of Mood States

Lorr (1989) stated that presently most of the mood states are considered monopolar, thus lacking a semantic opposite as would be the case with bipolar mood states. The issue of bipolar versus monopolar mood states began with the work of Nowlis and Nowlis (1956), who constructed a mood adjective checklist to evaluate the emotional effects of drugs and emotional films. They proposed four bipolar dimensions: activation-deactivation, positive-negative social orientation, control-lack of control, and depression-elation. However, subsequent analysis by Green and Nowlis (1957) revealed eight monopolar factors rather than four bipolar factors. Investigations by other researchers (Borgatta, 1961; McNair & Lorr, 1964; Thayer, 1967) also revealed monopolar affective states rather than bipolar affective dimensions.

However, Meddis (1972) reported potential sources of bias in response formats used by Nowlis (1965) and Thayer (1967) that could account for their failure to obtain bipolar dimensions. The scaling format used in these studies was asymmetrical in that it offered an unequal number of positive and negative categories (e.g., No (definitely not), ? (cannot decide), V (feel slightly), VV (definitely feel)). Using a symmetrical scaling format of definitely feel, feel slightly, do not feel, and definitely do not feel, with the same adjectives as used in previous studies, Meddis (1972) found bipolar mood factors. Meddis concluded that obtaining bipolar factors depends on the rating scales used.

Russell (1979) indicated that factors in addition to response format biased the reporting of bipolar and monopolar mood states. Methodologically, if chosen affective words bias one end of a bipolar dimension, bipolar factors are less likely to emerge. Second, if subjects are asked to respond according to how they have felt over a period of time, they may describe several and perhaps opposite emotional experiences. A third point Russell noted was that correlations between two items on a scale are spuriously inflated to the proximity of the items to each other in time or space. This is referred to as proximity error and may result in a shift toward more positive correlations among a group of items. Another factor potentially leading to monopolar affective states is an acquiescence response bias. Acquiescence is an individual difference variable that represents a tendency to respond consistently to items (e.g., agree, disagree) ignoring the content of particular items.

Acknowledging previous methodological shortcomings, Russell (1979) conducted a study of self-reported affect using items representing pleasure-displeasure, arousal-sleepiness, dominance-submissiveness, adjectives from Thayer's four scales of activation, and a set of adjectives to assess depression. Four different response formats were used: Meddis' (1972) - XX (definitely do not feel), X (do not feel), V (slightly feel), VV (definitely feel); Nowlis (1965) and Thayer (1967) - No (definitely do not feel), ? (cannot decide), V (feel slightly), VV (definitely feel); McNair and Lorr (1964) - 1 (not at all), 2 (a little), 3 (quite a lot), 4 (extremely); True-false - N (no, I do not feel), Y (yes, I do feel). Each subject responded four times, once to each 58-item inventory using each of the above response formats. Russell (1979) found that the Meddis format resulted in a symmetrical distribution whereas the others resulted in bimodal and skewed distributions. Thus, the other response formats resulted in correlations shifted in a positive direction, away from bipolarity. Furthermore, when acquiescence was partialled out, correlations shifted in the direction supporting bipolarity. Based upon these results, Russell (1979) concluded that affective space is more than one dimension and directional, thus bipolar.

Lorr, McNair, and Fisher (1982) also provided support for the bipolarity of mood states. A 72-item Profile of Mood States (POMS) was administered to 303 psychiatric patients. Lorr et al. (1982) found that the 72 adjectives were intercorrelated with one another. The adjectives also correlated with a measure of extreme response bias which consisted of the sum of all adjective ratings by a subject. After partialling out variance due to extreme response bias, they conducted a principal components analysis and found a rotated oblique factor solution with five bipolar factors: elated-depressed, agreeable-hostile, energetic-tired, composed-anxious, and clear thinking-confused.

Results from the studies by Lorr et al. (1982) and Russell (1979) support a bipolar structure of mood states. The results also suggest that researchers should consider response formats and potential acquiescence response bias when assessing mood and affect.

The literature reviewed in this section suggests that mood states are bipolar with semantic opposites. The next issue in analysis and assessment of mood and affect concerns the dimensions of mood and affect. Presently, there are primarily two models used in the study of the structure of mood and affect, a dimensional model and a structural, circumplex model.

Structural and Dimensional Models of Mood and Affect

Watson and Tellegen (1985) reanalyzed several studies of self-reported mood and found that positive and negative affect consistently emerged as the first two Varimax rotated factors in orthogonal factor analyses or as the first two second order factors in oblique factor analysis solutions. Watson and Tellegen (1985) developed a two-dimensional model of affect. The first dimension included descriptors such as active, elated, enthusiastic, excited, peppy, strong, and on the opposite end drowsy, dull, sleep, and sluggish. The second dimension included distressed, fearful, hostile, jittery, nervous, scornful, and on the opposite pole at rest, calm, placid, and relaxed. Watson and Tellegen (1985) labeled the two dimensions positive and negative affect.

Watson and Tellegen's (1985) model proposed two general dimensions, positive and negative affect, with an orthogonal independent relationship. However, Diener and Emmons (1985) argued that positive and negative affect are bipolar rather than independent. For example, a person in a positive mood will experience less negative affect. Diener and Emmons (1985) have found that over time positive and negative affect are independent, but for mood assessments made on the same day there is a strong inverse correlation between positive and negative affect. Diener, Larsen, Levine, and Emmons (1985) found that intensity and frequency dimensions helped explain the independence of positive and negative affect over time.

Rather than examining emotions along one dimension, Russell (1980) proposed a circumplex structural model consisting of a set of interrelated dimensions. Russell (1980) justified the heuristic value of a structural, circumplex model on several grounds. First, it would be unrealistic to attempt to formulate a list of all the emotions we experience. Second, a list only allows two alternatives, new emotion words or synonyms for words already on the list. Additionally, lists cannot represent the degree of similarity between emotions. Finally, emotional words and categories are not independent, but rather are systematically and highly interrelated. A structural model attempts to represent interrelationships between emotional terms.

Russell's (1980) proposed model conceptualizes affect along a set of interrelated dimensions. Affective concepts fall in a circle along the following dimensional axes: pleasure (0), displeasure (180), excitement (45), depression (225), arousal (90), sleepiness (270), distress (135) and relaxation (315). There are two main bipolar dimensions; the horizontal dimension represents pleasure-displeasure and the vertical dimension represents an arousal continuum from sleep states to high arousal. Additionally, there are four affective quadrants: I, pleasure/high arousal; II, displeasure/high arousal; III, displeasure/low arousal; and IV, pleasure/low arousal.

In conclusion, there is no consensus concerning the structure of affect or mood. Russell (1980) concluded that the experience of an affective state results from a cognitive process. Thus, the circumplex model proposed by Russell (1980) is a cognitive conceptual structure of affect that appears to capture the bipolar and multidimensional structure of affect and mood.

Measurement of Mood and Affect

Based upon conceptions of the structure of mood and affect, several inventories have been developed to assess mood and affect. The inventories that will be reviewed are those that have been used in sport and exercise psychology or with potential applicability in sport and exercise psychology

Zuckerman and Lubin (1965) developed the Multiple Affect Adjective Check List (MAACL) to measure anxiety, depression, and hostility. The anxiety scale consists of 21 adjectives, the depression scale consists of 40 adjectives, and the hostility scale consists of 28 adjectives. Each scale is composed of positive and negative adjectives. A recent factor analysis of the MAACL by Gotlib and Meyer (1986) revealed two unipolar factors. One factor defined by the negative adjectives and the other factor defined by the positive adjectives. Based upon the results of this factor analysis, researchers in sport and exercise psychology should not use the MAACL to examine mood and affect as the inventory does not correspond with current bipolar conceptions of emotion.

A widely used measure of mood is the Profile of Mood States (POMS) developed by McNair, Lorr, and Droppleman (1971). The POMS consists of 65 adjectives rated on a 5-point scale that measures six mood/affective states. Factors identified on the POMS are tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia, vigor-activity, and confusion.

There are several limitations and weaknesses of the POMS and MAACL when they are used in sport and exercise settings. Conceptually, the POMS and MAACL portray mood as multidimensional, however, the dimensions along which moods vary are not specified (e.g., positive-negative, arousal-sleep). Additionally, these inventories contain a large number of items and factors without much theoretical or conceptual guidance. In terms of administration of the POMS and MAACL in sport and exercise settings, the inventories may be cumbersome and time consuming, with the potential for response bias if the inventories are completed frequently over a short period of time. Also, these inventories were developed for use with clinical (psychiatric) populations, and this may limit generalizability with apparently normal individuals in sport and exercise settings.

Another inventory often used to assess mood is Thayer's (1967, 1986) Activation-Deactivation Adjective Check List (AD-ACL). According to Thayer, activation ranges on a continuum from deep sleep to excitement. The AD-ACL has a 4-point response format and factor analyses have revealed four factors: general activation (lively, active, full of pep, energetic); high activation (clutched up, jittery, stirred up, intense); general deactivation (at rest, leisurely, quiescent); and deactivation-sleep (sleepy, tired, drowsy). These factors also correlate with physiological variables. Although subsequent analyses (Thayer, 1986) have found that deactivation-sleep (tiredness) and high activation (tension) are bipolar factors, the bipolarity of the other factors has not been supported.

A recently developed inventory for the assessment of mood and affect is the Positive and Negative Affect Schedule (PANAS) developed by Watson, Clark, and Tellegen

(1988). The Positive Affect Scale consists of the following 10 items: attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong, and active. The Negative Affect Scale consists of the following adjectives: distressed, upset, hostile, irritable, scared, afraid, ashamed, guilty, nervous, and jittery. Respondents rate each item on a 5-point scale. Unlike the POMS and MAACL, the PANAS was developed to assess positive and negative dimensions of affect, and reliability and validity established with undergraduate and nonstudent adult populations (Watson, Clark, & Tellegen, 1984; Watson & Tellegen, 1985; Zevon & Tellegen, 1982). This instrument has promise for use in sport and exercise psychology due to its ease of administration and assessment of positive and negative affect.

Another recently developed instrument for the assessment of affect is the Affect Grid (Russell, Weiss, & Mendelsohn, 1989). The Affect Grid is a single item response scale of pleasure-displeasure and arousal-sleepiness, which has been used to assess current mood. The Affect Grid requires respondents to place a single mark on a 9 X 9 grid. Like the PANAS, the Affect Grid may be useful sport and exercise settings, particularly when immediate responses are desired.

In summary, several inventories exist for the measurement of mood and affect. Researchers should use inventories that control for response format and subject response biases. In choosing an inventory researchers should also consider the theoretical or conceptual basis underlying the development of an assessment instrument. Based upon the inventories reviewed and the above mentioned factors, the PANAS and Affect Grid appear to be viable instruments for the assessment of mood and affect in sport and exercise psychology.

Increased Training

It is generally accepted that success in endurance events requires progressive training load increases. However, there may be consequences associated with increasing the volume and/or intensity of a particular training session. Over a period of time, overtraining, defined as a short-term phenomenon or process of overworking an athlete (Kuipers & Keizer, 1988), may result. Overtraining involves an imbalance between training and recovery from work bouts, eventually leading to declines in work capacity, increased fatigue, and decreased performance.

Fatigue is associated with overtraining and is the result of insufficient recovery from previous training bouts (Palmer & Goldfarb, 1979). Insufficient recovery does not allow for complete restoration of cellular homeostasis, which may lead to premature fatigue and decreased maximal work outputs in subsequent training sessions. Because of insufficient or incomplete recovery, motor units that are normally recruited and involved in a particular type and intensity of exercise may be prematurely fatigued. Thus, meeting the energy demands of a given workload, may require increased nervous stimulation of motor units or additional recruitment of motor units. This alteration in motor unit recruitment may lead to an increased oxygen cost, increased heart rate, increased ventilation, and increased blood lactate at a given workload (Kuipers, Verstappen, Keizer, Geurten, & VanKranenburg, 1985). This differential recruitment pattern of motor units at a given workload and higher ventilation and lactate levels can result in subjective evaluations that a given workload is imposing a greater demand on an individual in comparison to a well-rested condition (Kuipers & Keizer, 1988).

Fatigue can be associated with the process of overtraining. A more serious problem associated with long-term overtraining is staleness. Brown, Frederick, Falsetti, Burke, and Ryan (1983) found that a variety of symptoms may be associated with staleness, including: increased resting heart rate, delayed return of heart rate after exercise, muscle soreness, lower body weight, decreased appetite, increased fluid intake, and altered sleep patterns. However, performance decrements are the most dramatic indicators of overtraining.

Even though performance decrements are a major indicator of overtraining, often there can be alterations in physical parameters associated with the overtrained state (e.g., increased resting heart rate, increased cortisol, increased plasma creatine kinase) and there may or may not be decrements in performance (Kirwan, Costill, Flynn, Mitchell, Fink, Neufer, & Houmard, 1988). Kirwan et al. (1988) examined physiological responses during a twofold increase in training volume (increased distance, maintained intensity) over a 10-day period in college swimmers. Kirwan et al. (1988) found that increased training resulted in increased pre-exercise plasma cortisol and plasma creatine kinase concentrations, increased hemoglobin and hematocrit, increased resting catecholamine concentrations, and decreased resting blood lactate concentrations. Swimming performance and power were unaffected by the increased training. Thus, Kirwan et al. (1988) concluded that the swimmers did experience stress as a result of the increased training load, yet were not overtrained because performance was not impaired.

A possible mechanism for increased resting cortisol concentrations is increased secretion by the adrenal gland. In the normal rested state, cortisol works with other hormones to ensure normal metabolism, provide energy, and increase the rate at which proteins are catabolized and amino acids removed from cells (e.g., muscle cells). Cortisol also stimulates the release of fatty acids from adipose tissue for energy. Stress (e.g., increased exercise intensity) may stimulate increased secretion of cortisol. Stress results in hypothalamus stimulation which results in secretion of corticotropin releasing factor and subsequently initiates the release of ACTH from the pituitary and cortisol production and secretion. The increased cortisol associated with increased training may also be due to its anti-inflammatory role. Kirwan et al. (1988) reported increased creatine kinase with increased training, suggesting that muscle damage may have occurred during increased training; thus, increased cortisol may help inhibit inflammation from muscle damage.

Costill, Flynn, Kirwan, Houmard, Mitchell, Thomas, and Han Park (1988) examined deltoid muscle glycogen concentrations in these same swimmers during the increased training period. Costill et al. (1988) found reduced muscle glycogen concentrations in samples from the posterior deltoid. These swimmers reported increased muscular fatigue, had lower heart rates and blood lactate concentrations during submaximal swims. Decreased resting lactate concentrations may have reflected an increased use of fat as a source of energy due to decreases in muscle glycogen. Swimming power, sprinting performance, endurance performance, aerobic capacity, and muscle citrate synthase did not change as a result of increased training. Interestingly, four swimmers were not able to tolerate the increased workload as well as the others and swam at a slower speed during training sessions. Compared to the other swimmers, these four individuals had lower glycogen concentrations before and after the increased training period, they also consumed less carbohydrates, and did not maintain energy balance (caloric intake) during the increased training. Despite physiological indicators, these four swimmers were not overtrained because their performance did not change. Costill et al. (1988) suggested that the fatigue experienced by the swimmers may have resulted from failure to ingest sufficient carbohydrates during the increased training.

Because carbohydrate intake may influence physiological responses to increased training, Kirwan, Costill, Mitchell, Houmard, Flynn, Fink, and Beltz (1988) altered carbohydrate intake during a period of increased training. Ten distance runners increased their training load for 5 days (20 km·day, 80% $\dot{V}O_2max$). Runners ingested either a diet in which carbohydrate composition equalled their daily expenditure (EQ-CHO) or was 50% less (LO-CHO) than their daily expenditure. During Days 3 and 5 of the increased training, glycogen concentration in the gastrocnemius was lower for those on the LO-CHO diet. For those on the EQ-CHO diet, glycogen concentration was lower after five days of increased training. Running economy was worse during 185 $m \cdot min^{-1}$ and 238 $m \cdot min^{-1}$ runs during the LO-CHO diet and ratings of perceived exertion were higher during the 238 $m \cdot min^{-1}$ run. After three days rest, running economy returned to normal, ratings of perceived exertion returned to pretraining levels and glycogen was 85% of pretrained levels. Thus, these runners were not overtrained but were metabolically affected by the increased training.

The studies reviewed in this section reveal that responses to increased training occur relatively quickly, usually within three days. Interestingly, while an individual can be physically stressed, often performance is not impaired. The studies also suggest that diet, particularly carbohydrate intake may influence responses to increased training. Although the physiological responses to a period of increased training and fatigue are known, psychological responses to increased training are still not clearly understood. It may be important to further understand associations between psychological and physiological responses to increased training loads so that staleness from overtraining can be prevented.

Summary

Examination of mood and affect within sport and exercise settings should be based upon theoretical or conceptual grounds. Thus far in sport and exercise psychology, with few exceptions (Ainsworth et al., 1990; Hardy & Rejeski, 1989), theoretical, conceptual, and measurement issues have been ignored when examining mood and affect.

Considering that mood and affect are distinct terms, distinguished by intensity and duration or persistence, one must carefully define and measure mood and affect. POMS was developed as a general measure of mood, which asks individuals to respond based on how they have been feeling during the past week. Validity has not been demonstrated for right now or today responses. Another difficulty is that the POMS was developed for use with psychiatric patients, and thus its generalizability for use with exercisers and athletes may be limited.

The PANAS and Affect Grid may be better measures for examining affective responses to exercise. Both instruments are relatively new and have not been extensively used in exercise settings. The PANAS can be used as a measure of affect in which individuals respond as to how they are feeling at a particular moment, or as a measure of mood, how have you felt today, past few days, week, weeks, etc. Another advantage is that the PANAS is less cumbersome than the POMS. The PANAS allows for the measurement of both positive and negative affect and validity and reliability has been established with undergraduate and nonstudent adult populations. The Affect Grid may be an even better measure of affect. Russell et al. (1989) developed the Affect Grid such that it represents the two main dimensions of mood, arousal and pleasure. The Affect Grid allows for quick and immediate responses, and its format minimizes response format bias as well as acquiescence bias. Like the Feeling Scale, the Affect Grid may be a viable instrument for the measurement of affect during exercise.

The effects of training on emotional states and interactions between psychological and physiological responses have been neglected in work on affect, mood and exercise. Studies have examined acute effects of mood, affect, and exercise, generally finding that exercise enhances mood and affect. Few studies have examined associations between mood/affective responses and physiological responses. Theoretically and conceptually, emotions have both a physiological and cognitive component. Exercise would therefore appear to be an ideal stimuli in which to examine interactions between physiological and cognitive responses.

Unique characteristics of exercise loads, such as intensity, duration, and frequency components may differentially influence mood and affect. The focus of this exploratory study was to examine psychological and physiological responses associated with normal baseline and increased training. Physiological responses associated with training are fairly well documented, but less is known about psychological responses and the interaction between psychological and physiological responses during increased training. Results of this study may have implications for well being and mental health, and further our understanding of exercise behavior and associations bewteen psychological and physiological responses to exercise.

CHAPTER III

METHOD

This chapter outlines the procedures employed in the study. The method chapter consists of the following sections: (a) subjects, (b) dependent variables, (c) testing procedures, and (d) data analysis.

Subjects

Six moderately trained male and five moderately trained female endurance runners between the ages of 19 and 44 participated in the study (M = 31.40 ± 8.13 years). Participants were selected based upon previous race times (males: 38 - 45 min 10KM within past year; females: 41 - 48 min 10KM within past year), physiological capacity (males: approximately 50 - 60 $ml \cdot kg^{-1} min^{-1}$ $\dot{V}O_2max$ (M = 55.51 ± 5.24 $ml \cdot kg^{-1} min^{-1}$), females: approximately 40 - 50 $ml \cdot kg^{-1} min^{-1}$ $\dot{V}O_2max$ (M = 47.79 ± 1.90 $ml \cdot kg^{-1} min^{-1}$); and weekly training distance (20 - 40 $miles \cdot week^{-1}$). The combined male and female subjects' mean ± SD physical characteristics were: weight 67.11 ± 10.31 kg; $\dot{V}O_2max$ 51.65 ± 5.81 $ml \cdot kg^{-1} min^{-1}$; weekly training distance 22.5 ± 5.66 mi. Runners did not complete any running outside of the study during the baseline and increased training period. Testing occurred at approximately the same time of day for each participant.

Informed consent was obtained from all subjects prior to participation in the study (Appendix A). Participants completed a Health Screening questionnaire (Appendix B) that adhered to ACSM guidelines to clear individuals participating in exercise testing and the training protocols. Participants completed a Performance Questionnaire (Appendix C) to ensure that runners selected for participation had engaged in a running program for 12 months prior to the study and met performance qualifications for the study.

Dependent Measures

Positive and Negative Affect Schedule (PANAS). Developed by Watson, Clark and Tellegen (1988), the PANAS assesses positive and negative mood and affect. The positive (PA) and negative (NA) affect scales are composed of 10 items (see Appendix D). Respondents rated each item on a 5-point Likert type scale. Watson et al. (1988) reported internal consistency reliabilities ranging from .86 to .90 for PA and .84 to .87 for NA, and adequate test-retest reliabilities which vary according to the time frame sampled (e.g., moment, today, past few days, past week, past few weeks, year).

Affect Grid. Developed by Russell, Weiss, and Mendelsohn (1989), the Affect Grid is a single-item response scale measuring pleasure-displeasure and arousal-sleepiness dimensions of affect. The Affect Grid (Appendix E) can be used to assess current affect. The 9 X 9 Grid required respondents to place a single mark on the grid. The scale has adequate reliability, convergent validity, and discriminant validity.

Profile of Mood States (POMS). The 65-item Profile of Mood States (Appendix F) developed by McNair, Lorr, and Droppleman (1971) assessed mood states. The inventory consists of six subscales: tension, depression, anger, vigor, fatigue, and confusion. Participants rated each item on a 5-point Likert scale. McNair et al. (1971) reported test-retest reliability coefficients that ranged from .65 to .74.

Incredibly Short Profile of Mood States (ISP). Dean, Whelan, and Meyers (1990) developed a shorter, 6-item POMS (Appendix G) which allows for quick and efficient assessment of mood states. The 6 items are tension, depression, confusion, vigor, fatigue, and anger. Respondents rated each item as the original POMS items are rated, on a 5-point scale ranging from "not at all" to "extremely". Dean et al. (1990) reported that the ISP correlated with the six subscales of the POMS

(range: *r* = .67, to *r* = .82)

Rating of Perceived Exertion (RPE). The RPE scale, (Appendix H) developed by Borg (1985) requires respondents to rate the total amount of exertion they feel during a particular workbout. The scale ranges from 6 to 20, with verbal anchors at each odd number (e.g., 7 = very, very light, 19 = very, very hard). Borg (1985) has reported adequate psychometric properties for the RPE scale.

Feeling Scale (FS). Developed by Hardy and Rejeski (1989), the Feeling Scale (Appendix I) is used to measure affect during exercise. The 11-item scale ranges from +5 to -5. Verbal anchors are provided at 0 and odd integers (e.g., +5 = very good, -5 = very bad). Validity has not yet been established for the Feeling Scale.

Physiological Measures. Oxygen uptake was determined using standard open-circuit methods. Expired air was collected in meterological balloons for 1 min during the baseline and increased training runs at times representing 33% and 67% of the total time of the run. Expired air was collected during the $\dot{V}O_2max$ test for 1 min periods after a heart rate of 160 $b \cdot min^{-1}$ was reached and air collections continued until the graded exercise test ended. Balloons were analyzed for oxygen (O_2)and carbon dioxide (CO_2) concentrations using Ametek Applied Electrochemistry O_2 (S-3A/I) and CO_2 (CD-3A) analyzers.

Analyzers were calibrated before and after each subject's run using gases of known concentrations. Gas volumes were determined by evacuating expired air from the balloon into a Rayfield gas meter. Oxygen consumption was computed with a software program based upon standard equations for open circuit collection methods (McArdle, Katch, & Katch, 1986) using volume, collection time, CO_2, and O_2 values corrected standard, temperature, pressure, dry (STPD).

Heart rate was monitored with a Polar heart rate monitor during each day of the baseline and increased training runs and recorded when air samples were collected.

Testing Procedures

Participants were informed of purposes and procedures of the study and informed consent was obtained during the initial testing session. During the initial session, participants were given a dietary log (Appendix J) and asked to record their diet during the five days of baseline training and five days of increased training. Each day of the baseline training and increased training sessions participants turned in dietary logs completed for the previous day. Prior to beginning the increased training period, diets were analyzed and all runners instructed to maintain a high carbohydrate intake

(65% - 70% of total daily intake) during the increased training period. Previous research (Kirwan et al., 1988) suggests that carbohydrate intake during a period of increased training may affect glycogen storage and subsequently endurance and performance. Therefore, runners were asked to record their daily diet and instructed to maintain or increase their carbohydrate consumption during the course of the increased training period to minimize potential glycogen depletion. Additionally, to prevent or minimize glycogen depletion, exercise bouts were completed at 70% - 75% of maximal oxygen uptake, as work rates and endurance above this level are influenced by initial skeletal muscle glycogen concentrations (Astrand & Rodahl, 1986).

Session 1. Maximal oxygen uptake was determined during the first testing session. Participants completed a 1.5 min warm-up at 188 $m \cdot min^{-1}$ (8:30 min pace) followed by 1.5 min warm-up at 200 $m \cdot min^{-1}$ (8:00 min pace). After the 3-min warm-up, the speed remained constant at 200 $m \cdot min^{-1}$ and treadmill elevation increased 2.5% every 2 min until the subject reached volitional exhaustion. Heart rate was monitored continuously with a 6-lead ECG and HR values recorded at the end of each minute of exercise. Expired air was collected in meterological balloons for 1-min periods after a heart rate of 160 $b \cdot min^{-1}$ was reached and air collection continued until the graded exercise test terminated.

Sessions 2 through 6 (Days 1 - 5, Baseline Training).

The baseline, normal training period began two to three days after the maximal oxygen uptake test. Participant's average weekly running distance was determined from their Performance Questionnaire ($\underline{M}$ ± SD = 22.5 + 5.66 mi) and training conducted at their average weekly distance over five consecutive days (e.g., 20 $mi \cdot wk^{-1}$ ran 4 $mi \cdot day^{-1}$). The average daily distance was 4.5 ± 1.13 mi. The training velocity representing 75% maximal aerobic capacity was calculated for each runner. Training runs were completed at an average velocity of 199.47 ± 23.45 $m \cdot min^{-1}$ for 36.13 ± 7.09 min. Training runs were completed at 36.41 ± 4.11 $ml \cdot kg \cdot^{-1} min^{-1}$, representing 70% $\dot{V}O_2max$. The training velocity was kept constant during the baseline and increased training period.

Prior to and after each run, participants completed the PANAS, ISP, Affect Grid, and POMS. During the run, expired air was collected for 1 min at minutes representing 33% and 67% of the total time of the run. Heart rate was recorded at these times. After expired air samples were collected, runners were shown the RPE scale, Feeling Scale, Affect Grid, ISP, and PANAS and verbally responded to each of these measures. Figure 2 illustrates collection times and measures. On the last day of the baseline training period (Day 5), participants completed the PANAS, ISP, Affect Grid, and POMS based on "how they have felt during the past week" prior to completing the "moment" questionnaires before the run.

RUN

Prior to run	33% total run time	67% total run time	After run
(Pre)	(Time A)	(Time B)	(Post)
PANAS	RPE	RPE	PANAS
ISP	FS	FS	ISP
Affect Grid	Affect Grid	Affect Grid	Affect Grid
POMS	PANAS	PANAS	POMS
	ISP	ISP	

FIGURE 2. Collection Times and Measures During Run

Sessions 7 through 11 (Days 6 - 10, Increased Training).

The increased training period began two days after Day 5. Increased training was conducted at 1.5 times the participant's average weekly distance for 5 consecutive days (e.g., average distance 20 $mi \cdot week^{-1}$ trained at 30 $mi \cdot week^{-1}$, 6 $mi \cdot day^{-1}$). Average weekly distance was 33.75 ± 8.49 mi, and 6.75 ± 1.70 $mi \cdot day^{-1}$. Runs were completed at the same velocity as during the baseline training. Runs were completed at an average intensity of 36.80 ± 4.38 $ml \cdot kg \cdot^{-1} min^{-1}$ representing 71% $\dot{V}O_2max$.

Average run time during the increased training period was 54.20 $\pm$ 10.64 min.

Prior to and after running, participants completed the PANAS, ISP, Affect Grid, and POMS responding "how they feel at that moment". During the run, expired air was collected for 1 min at minutes representing 33% and 67% of the total time of the run. Heart rate was recorded at these times. After expired air samples were collected, runners were shown the RPE scale, Feeling Scale, Affect Grid, ISP, and PANAS and verbally responded to each of these measures. On the last day of the increased training period (Day 10), participants completed the PANAS, ISP, Affect Grid, and POMS based on "how they have felt during the past week" prior to completing the "moment" questionnaires before the run.

Data Analysis

Differences between psychological and physiological responses during a period of normal baseline training and during a period of increased training was the main comparison of the study. A series of repeated measures ANOVAs were conducted to compare averaged weekly psychological and physiological responses during the baseline and increased training weeks. To examine changes across time within sessions, Week X Time (2 X 2) and (2 x 4) repeated measures ANOVAs were conducted.

Week X Day (2 X 5) repeated measures ANOVAs were conducted to examine changes across days within the two weeks.

Daily dietary records were analyzed for total energy intake, and carbohydrate, fat, and protein composition using a computer software program (N-Squared Computer Software).

CHAPTER IV

RESULTS

Analyses

The main analysis of this study was differences between psychological and physiological responses during a period of normal baseline training and during a period of increased training. Separate ANOVAs rather than MANOVAs were conducted for each of the dependent variables due to the small sample size, and multiple measures. Because multiple univariate tests were conducted, there is the possibility of error inflation. Thus, the .05 level of significance selected may be greater, increasing the probability of a Type I error. Due to the exploratory nature of this study, the error inflation associated with multiple univariate tests seemed less consequential than violating assumptions of multivariate techniques. From this exploratory study, a smaller set of dependent variables may be generated and further examined during baseline and increased training periods.

Weekly Psychological and Physiological Responses During Normal and Increased Training

Responses to POMS, PANAS, ISP, and Affect Grid were averaged over 5 days (5 days of normal training, 5 days of increased training) and 4 times each day (prior to run, two collections during run at times representing 33% and 67% of total run time, and after run) to compute a weekly score for each measure. RPE, FS, and physiological responses were averaged over 5 days (5 days of normal training, 5 days of increased training) and 2 times each day (during run at times representing 33% and 67% of total run time) to compute a weekly score. Means and standard deviations for psychological and physiological measures along with the results of ANOVAs comparing normal and increased training weeks are presented in Tables 1 and 2.

Table 1

Means, Standard Deviations, F-ratios, and Effect Sizes for Averaged Psychological Measures During Baseline and Increased Training

	Baseline Training		Increased Training			
	M	SD	M	SD	F	ES
POMS						
TMD	108.41	20.71	98.53	13.78	10.44*	.57
Tension	7.78	5.52	4.82	2.97	8.38*	.51
Depression	3.53	3.73	1.83	1.90	6.81*	.46
Anger	3.61	3.76	1.39	1.63	7.73*	.49
Vigor	17.69	4.86	17.60	5.98	0.01	.00
Fatigue	5.37	4.78	3.94	3.72	4.22	.35
Confusion	5.81	3.66	4.14	2.52	7.74*	.49
ISP						
TMD	9.75	1.64	9.26	1.76	3.20	.31
PANAS						
Positive	32.23	7.03	32.24	7.70	0.00	.00
Negative	12.02	1.74	10.98	0.89	7.76*	.49

Table 1 (cont.)

Affect Grid						
Row	6.65	0.58	6.78	0.71	0.33	.04
Column	6.35	1.07	6.45	1.07	0.28	.03
RPE	12.08	1.54	12.56	1.95	3.76	.29
FS	2.47	0.88	2.37	1.01	0.83	.08

*$p < .05$

Repeated measures ANOVAs were conducted to examine whether psychological responses during a period of baseline training (BT) are similar to psychological responses during a period of increased training (IT). Results revealed a significant week main effect for the POMS total mood disturbance, $F(1,8) = 10.44$, $p < .05$. Total mood disturbance, a composite measure of mood computed by summing negative POMS moods (i.e., tension, depression, anger, fatigue, confusion), and then subtracting the vigor score and adding a constant of 100, was lower during the increased training week. There were also significant week effects for tension/anxiety, $F(1,8) = 8.38$, $p < .05$; depression, $F(1,8) = 6.81$, $p < .05$; anger, $F(1,8) = 7.73$, $p < .05$; and confusion, $F(1,8) = 7.74$, $p < .05$. Tension/anxiety, depression, anger, and confusion were lower during the week of increased training. The results for individual POMS subscales and the composite mood score indicate that mood was less negative during the increased training week than during the baseline training week.

Results of a repeated measures ANOVA on PANAS subscales revealed a significant week main effect for negative affect, $F(1,8) = 7.76$, $p < .05$. Negative affect during the increased training week was lower than during the baseline training week.

There were no significant week main effects for the Incredibly Short POMS, Affect Grid, RPE, or FS.

To examine whether the POMS assesses similar affective states as the ISP, PANAS, Affect Grid, RPE, and FS correlations between these measures and POMS were conducted. Results, presented in Table 2, revealed high to moderate correlations between POMS and the other measures. POMS total mood disturbance was positively correlated with ISP total mood disturbance, and negatively correlated with PANAS positive affect, Affect Grid pleasure and arousal responses, and FS responses. These negative correlations indicate that greater total mood disturbance is associated with lower positive affect, pleasantness, and arousal. Interestingly, RPE was negatively correlated with the POMS vigor subscale and positively correlated with the fatigue subscale. Thus, perceptions of exertion may represent a state of increased fatigue and decreased energy (vigor). Overall, correlational results revealed that the POMS, particularly total mood disturbance, is moderately correlated with other inventories (ISP, PANAS, Affect Grid, RPE, and FS) assessing positive and negative as well as pleasure and arousal dimensions of affect.

Table 2

Correlations Among POMS Subscales and ISP, PANAS, Affect Grid, RPE, and FS Averaged Weekly Responses

POMS Subscales

	TMD r	Tension r	Depr r	Anger r	Vigor r	Fatigue r	Conf r
POMS							
TMD		.80**	.68*	.82**	-.88**	.67*	.87**
Tens			.23	.51	-.64	.39	.73*
Depr				.65	-.47	.37	.70*
Ang					-.54	.27	.67
Vig						-.75*	.26
ISP							
TMD	.88**	.52	.62	.74**	-.78*	.69	.59
PANAS							
Pos	-.94**	-.83**	-.53	-.74*	.91**	-.56	-.81**
Neg	.71*	.47	.57	.88**	-.59	.23	.77*
AFFECT GRID							
Pleas	-.68*	-.52	-.69*	-.55	.54	-.41	-.56
Arous	-.68*	-.33	-.39	-.42	.83**	-.69*	-.48
RPE	.65	.21	.26	.14	-.88**	.88**	.26
FS	-.86**	-.62	-.72*	-.66	.70*	-.75*	-.61

*$p < .05$ **$p < .01$

Repeated measures ANOVAs conducted to examine changes in physiological measures from the baseline training week to the increased training week are shown in Table 3 and revealed a significant week main effect for ventilation, $\underline{F}(1,6) = 11.73$, $\underline{p}$, $< .05$. Ventilations during the increased training week were higher than the baseline training week. There were no significant changes in any of the other physiological measures.

Table 3

Means, Standard Deviations, F-ratios, and Effect Sizes for Physiological Measures Averaged over Days and Time

	Baseline Training		Increased Training			
Measure	M	SD	M	SD	F	ES
Weight (lb)	150.40	22.83	149.92	22.03	1.26	.14
$\dot{V}O_2$ ($ml \cdot kg^{-1} min^{-1}$)	36.41	4.11	36.80	4.38	3.89	.39
$\dot{V}O_2$ ($l \cdot min^{-1}$)	2.49	0.50	2.51	0.53	1.61	.21
$\dot{V}_E$ ($l \cdot min^{-1}$)	56.59	10.24	58.24	10.26	11.73*	.66
RER	0.94	0.03	0.93	0.04	2.30	.27
HR ($b \cdot min^{-1}$)	150.75	6.42	152.70	6.58	2.18	.24

*$p < .05$

A series of repeated measures ANOVAs were conducted to examine changes in dietary intake during the baseline and increased training week. Results revealed no significant differences between baseline training and increased training total caloric intake, carbohydrate intake, fat intake, or protein intake. Table 4 presents means, standard deviations, F-ratios, and effect sizes for dietary intake during the two weeks of training.

Table 4

Means, Standard Deviations, F-ratios, and Effect Sizes for Dietary Intake

	Normal Training M (SD)	Increased Training M (SD)	F	ES
Total kcal	2380.31 (1116.17)	2631.03 (1973.20)	0.54	.08
CHO %total kcal	59.29 (11.91)	60.83 (11.48)	0.54	.08
Fat %total kcal	24.03 (9.50)	24.51 (10.01)	0.06	.00
Protein %total kcal	14.20 (3.54)	13.57 (4.35)	0.53	.08

In summary, the results of the averaged weekly psychological responses indicate that mood became less negative during the increased training week as compared to the baseline training week. Furthermore, based on the physiological variables examined, the runners were not any more stressed physiologically by the increased training load compared to the baseline training load.

<u>Temporal Changes in Psychological and Physiological Responses During Normal and Increased Training</u>

Responses to POMS, PANAS, ISP, Affect Grid, RPE, and FS were averaged over 5 days (5 days of baseline training, 5 days of increased training) to compute an average weekly time score for each response. Physiological responses were averaged over 5 days (5 days of baseline training, 5 days of increased training) and an average time score computed for each collection time during the baseline training week and increased training week.

A series of Week X Time (2 X 2) repeated measures ANOVAs were conducted to examine changes over time in POMS subscales. Week main effects are reported in the previous section. There was a significant time main effect for total mood disturbance, $F(1,8) = 7.81$, $p < .05$; confusion, $F(1,8) = 10.29$, $p < .05$; and depression, $F(1,8) = 13.48$, $p < .01$. Total mood disturbance, depression, and confusion before the run were greater than after the run. There were no significant week X time interactions for any of the POMS subscales. Table 5 presents means, standard deviations, F-ratios, and effect sizes for POMS subscales data at each collection time, collapsed over weeks. Overall, results of the POMS data indicates that mood was less negative after the run than before the run.

Table 5

Means, Standard Deviations, F-ratios, and Effect Sizes for POMS Subscale scores Pre and Post Run

	Pre M SD	Post M SD	F	ES
TMD	106.58 (17.57)	100.37 (17.04)	7.81*	.49
Tension	7.23 (4.47)	5.37 (4.34)	3.78	.32
Depression	3.07 (3.03)	2.30 (2.57)	13.48**	.63
Anger	2.84 (3.17)	2.16 (2.17)	2.62	.25
Vigor	16.31 (6.29)	18.98 (4.96)	3.59	.31
Fatigue	4.37 (3.76.)	4.94 (4.87)	0.46	.05
Confusion	5.38 (3.07)	4.58 (2.99)	10.29**	.56

*$p < .05$ **$p < .01$

A Week X Time (2 X 4) repeated measures ANOVA conducted on the PANAS positive affect scores revealed a significant time effect, $F(3,24) = 8.50$, $p < .01$. Univariate contrasts revealed that positive affect before the run was lower than positive affect after the run Thus, positive affect increased during the run. The increase in positive affect was gradual, as positive affect at collection times A and B were also greater than affect prior to the run. There was no significant week X time interaction.

A Week X Time (2 X 4) repeated measures ANOVA conducted on the PANAS negative affect scores revealed a significant time effect, $F(3,24) = 5.23$, $p < .01$. Univariate contrasts revealed that negative affect before the run was greater than negative affect at the second collection during the run. Thus, affect became less negative during the run.

Table 6 present means means, standard deviations, F-ratios, and effect sizes for ISP, PANAS, Affect Grid, RPE, and FS responses at each collection time collapsed over weeks.

Table 6

Incredibly Short POMS, Positive and Negative Affect, and Affect Grid Responses, Pre, Post, and During Run

	Pre M SD	A M SD	B M SD	Post M SD	F	ES
ISP	10.08	9.48	9.19	10.13	1.10	.14
	(1.77)	(1.49)	(1.83)	(2.89)		
PANAS						
Pos	30.17	31.94	32.43	34.40	8.50*	.52
	(7.13)	(7.18)	(8.02)	(7.25)		
Neg	12.11	11.58	11.02	11.29	5.23*	.40
	(1.61)	(1.19)	(1.12)	(1.50)		
AFFECT GRID						
Pleas	6.00	6.60	6.94	7.31	7.38**	.48
	(1.03)	(0.43)	(0.64)	(0.86)		
Arousal	5.88	6.40	6.51	6.81	6.86*	.46
	(1.32)	(0.99)	(1.08)	(0.99)		
RPE		11.82	12.82		27.61**	.75
		(1.54)	(1.92)			
FS		2.43	2.41		0.02	.00
		(0.82)	(1.09)			

*p < .01 **p .001

A Week X Time (2 X 4) repeated measures ANOVA conducted on the Affect Grid row response (represents pleasure dimension; 1, unpleasant to 9, extremely pleasant) revealed a significant time effect, $F(3,24) = 7.38$, $p < .001$. Univariate contrasts revealed that pleasantness after the run was significantly greater than pleasantness before the run. There was no significant week X time interaction.

A Week X Time (2 X 4) repeated measures ANOVA conducted on the Affect Grid column responses (arousal dimension; 1, sleep to 9, high arousal) revealed a significant time effect, $F(3,24) = 6.86$, $p < .01$. Arousal increased over the run and univariate contrasts revealed a significant increase from before the run to after the run. There was no significant week X time interaction.

Thus, the results of POMS, ISP, and PANAS responses, indicate that mood became more positive, and less negative over time. Mood improved over time (i.e., pre to post run) and changes occurred gradually during the run. Pleasantness and arousal dimensions of mood also improved during the run.

A Week X Time (2 x 2) repeated measures ANOVA conducted on RPE scores revealed a significant time effect, $F(1,9) = 27.61$, $p < .001$. RPE at collection

Time A was lower than collection Time B. Thus, perception of effort increased during the run.

A Week X Time (2 X 2) repeated measures ANOVA conducted on FS scores revealed a significant week X time interaction $\underline{F}(1,9) = 7.11$, $\underline{p} < .05$. During the baseline training week, FS responses increased slightly (i.e., became more positive) but during the increased training week, FS responses decreased slightly (i.e., became less positive).

A series of Week X Time (2 X 2) repeated measures ANOVAs conducted on physiological responses revealed significant time effects for the following: oxygen consumption ($ml \cdot kg \cdot^{-1} min^{-1}$), $\underline{F}(1,6) = 7.46$, $\underline{p} < .05$; oxygen consumption ($l \cdot min^{-1}$), $\underline{F}(1,6) = 7.03$, $\underline{p} < .05$; ventilation, $\underline{F}(1,6) = 8.38$ $\underline{p} < .05$; and heart rate, $\underline{F}(1,7) = 19.56$, $\underline{p} < .01$. There was a significant interaction effect for respiratory exchange ratios, Oxygen consumption ($ml \cdot kg \cdot^{-1} min^{-1}$ and $l \cdot min^{-1}$), ventilations, and heart rate at collection Time A were lower than Collection Time B. These changes in physiological responses from Time A to Time B represent normal responses to a continuous session of aerobic exercise (Astrand & Rodahl, 1986). Table 7 presents means, standard deviations, F-ratios, and effect sizes for the physiological data.

Table 7

Means, Standard Deviations, F-ratios, and Effect Sizes for Physiological Measures Averaged Over Days

Measure	Time A M SD	Time B M SD	F	ES
$\dot{V}O_2$ ($ml \cdot kg^{-1} min^{-1}$)	36.45 (4.15)	36.76 (4.33)	7.46*	.55
$\dot{V}O_2$ ($l \cdot min^{-1}$)	2.49 (0.51)	2.51 (0.52)	7.03*	.54
$\dot{V}_E$ (btps)	56.74 (9.88)	58.78 (10.80)	8.38*	.58
RER	0.94 (0.03)	0.93 (0.04)	2.96	.33
HR ($b \cdot min^{-1}$)	149.69 (5.57)	153.76 (7.06)	19.56**	.74

*$p < .05$ **$p < .01$

Daily Changes in Psychological and Physiological Responses During Normal and Increased Training

Responses to POMS, PANAS, ISP, Affect Grid, RPE, and FS were averaged over time for each measure and a daily score computed for each of the five days of normal training and five days of increased training. Physiological responses were also averaged over time to compute an average daily score for each of the physiological measures.

A series of Week X Day (2 X 5) repeated measures ANOVAs conducted on POMS subscales revealed a significant day effect for total mood disturbance, $F(4,32) = 3.42$, $p < .05$; tension/anxiety, $F(4,32) = 4.64$, $p < .01$; and anger, $F(4,32) = 3.15$, $p < .05$. There were no significant week X day interactions. Univariate contrasts were conducted to examine if mood across the five days each week significantly differed from the first day of the week. Results revealed that tension/anxiety on Day 2 was greater than Day 1, $F(1,8) = 5.69$, $p < .05$. Although there were significant day effects for total mood disturbance and anger, univariate contrasts did not reveal any days that were significantly different from Day 1. Table 8 presents means, standard deviations, F-ratios, and effect sizes for POMS responses.

As Table 8 suggests, POMS scores changed from day to day and became more positive and less negative over the 10 days of training. Additionally, looking at Table 8 it appears that responses on Day 2 differed from the other days of training.

Table 8

Means, Standard Deviations, F-ratios, and Effect Sizes for POMS Subscales Averaged over Time

	TMD M (SD)	Tension M (SD)	Depr M (SD)	Anger M (SD)	Vigor M (SD)	Fatigue M (SD)	Confusion M (SD)
WEEK 1							
1	107.17 (21.07)	6.67 (4.05)	6.72 (4.94)	3.33 (3.61)	19.00 (5.51)	5.06 (3.87)	6.17 (3.02)
2	121.44 (36.55)	11.06 (7.49)	5.61 (8.24)	8.56 (12.34)	16.44 (6.11)	5.28 (5.80)	7.39 (5.84)
3	105.44 (21.81)	8.28 (6.70)	1.78 (2.66)	2.28 (3.25)	18.11 (6.57)	6.33 (6.91)	4.89 (3.46)
4	107.67 (21.49)	7.50 (6.48)	3.50 (4.08)	2.17 (1.92)	17.17 (5.03)	6.22 (6.38)	5.44 (4.67)
5	100.33 (19.02)	5.39 (5.73)	1.83 (3.15)	1.72 (2.24)	17.72 (6.75)	3.94 (4.22)	5.17 (3.95)
WEEK 2							
1	101.72 (19.10)	5.17 (4.18)	2.50 (3.52)	1.61 (1.85)	16.61 (7.50)	4.39 (5.71)	4.67 (3.75)
2	102.89 (20.32)	5.44 (4.44)	2.56 (4.05)	1.78 (1.89)	15.50 (6.61)	4.33 (4.76)	4.28 (2.98)
3	96.67 (15.59)	4.61 (2.74)	1.67 (3.37)	1.06 (1.72)	18.17 (6.43)	3.50 (3.63)	4.00 (2.82)
4	97.72 (12.74)	4.44 (3.03)	1.56 (2.40)	1.11 (1.54)	18.11 (5.81)	4.61 (4.60)	4.11 (2.56)
5	93.67 (13.68)	4.44 (2.38)	0.89 (1.45)	1.39 (2.63)	19.61 (6.57)	2.89 (3.83)	3.67 (2.29)
F	3.42*	4.64*	2.20	3.15*	0.96	2.48	0.80
ES	.30	.37	.22	.28	.11	.24	.09

*$p < .05$

A Week X Day (2 X 5) repeated measures ANOVA conducted on ISP total mood disturbance revealed a significant day effect, $F(4,28) = 3.34$, $p < .05$. Univariate contrasts did not reveal any of the days to be significant from Day 1. Table 9, which presents means and standard deviations for Incredibly Short POMS total mood disturbance suggests that mood generally became less negative over days with the highest total mood disturbance on Day 2.

Table 9

Means and Standard Deviations for Incredibly Short POMS Total Mood Disturbance Averaged over Time

	Baseline Training		**Increased Training**	
Day	M	SD	M	SD
1	9.47	2.03	9.50	2.06
2	11.34	3.07	9.97	2.90
3	9.78	2.15	9.06	2.36
4	9.47	1.54	9.28	2.09
5	8.69	1.56	8.50	1.81

A Week X Day (2 x 5) repeated measures ANOVA conducted on PANAS positive affect scores revealed no significant day effect or week X day interaction. For negative affect, there was a significant day effect, $F(4,23) = 4.08$, $p < .01$. Univariate contrasts revealed that negative affect on Day 2 was significantly different from Day 1, $F(1,8) = 7.15$, $p < .05$. Day 2 scores were most negative, especially in the first week, and negative affect decreased over the remaining days. Means and standard deviations for PANAS positive and negative affect responses are presented in Table 10.

Table 10

Means and Standard Deviations for PANAS Positive Affect and Negative Affect Responses Averaged over Time

	Baseline Training		Increased Training	
	Positive	Negative	Positive	Negative
Day	M SD	M SD	M SD	M SD
1	34.08	11.56	32.00	11.36
	(8.69)	(1.47)	(9.16)	(1.46)
2	30.11	14.00	29.31	11.31
	(7.37)	(4.07)	(9.92)	(1.41)
3	31.00	11.39	32.89	10.89
	(8.02)	(1.46)	(7.39)	(1.54)
4	33.39	12.06	32.25	10.69
	(6.66)	(2.67)	(8.08)	(1.02)
5	32.56	11.08	34.78	10.67
	(7.43)	(1.68)	(7.90)	(1.17)

A Week X Day (2 X 5) repeated measures ANOVA conducted on Affect Grid row responses (pleasure dimension) revealed no significant day effect or day x time interaction. For column responses (arousal dimension), there was a significant day effect,

$F(4,32) = 6.38$, $p < .001$. Univariate contrasts revealed that arousal responses on Day 2 were significantly different from Day 1, $F(1, 8) = 15.46$, $p < .01$. Table 11 presents means and standard deviations for Affect Grid responses. Arousal responses on Day 2 were lower than the other days of training.

Table 11

Means and Standard Deviations for Affect Grid Responses Averaged over Time

DAY	**Baseline Training** Pleasure M SD	**Baseline Training** Arousal M SD	**Increased Training** Pleasure M SD	**Increased Training** Arousal M SD
1	7.08	6.89	6.53	6.42
	(0.70)	(0.95)	(1.03)	(1.23)
2	6.50	5.72	6.47	5.42
	(1.08)	(1.44)	(1.01)	(1.65)
3	6.56	5.97	6.64	6.89
	(1.10)	(1.61)	(0.76)	(1.17)
4	6.69	6.61	7.03	6.39
	(0.69)	(1.20)	(0.70)	(1.44)
5	6.42	6.56	7.22	7.14
	(0.96)	(1.18)	(0.90)	(1.38)

A Week X Day (2 X 5) repeated measures ANOVA conducted on RPE responses revealed no significant week, day, or interaction effects. A Week X Day (2 X 5) repeated measures ANOVA conducted on FS responses revealed a significant day effect, $F(4,36) = 2.99$, $p < .05$, and no significant week X day interaction. Univariate contrasts did not reveal any days significant from Day 1. Table 12, which presents means and standard deviations for RPE and FS responses suggests that Day 2 and Day 3 FS responses tended to be lower than Days 1, 4, and 5.

Table 12

Means and Standard Deviations for RPE and FS Responses Averaged over Time

	Baseline Training		Increased Training	
	RPE	FS	RPE	FS
DAY	M SD	M SD	M SD	M SD
1	12.05	2.85	12.45	2.60
	(1.28)	(0.94)	(2.18)	(1.20)
2	11.95	2.40	12.90	1.65
	(1.91)	(1.13)	(2.17)	(1.67)
3	12.50	1.85	12.80	2.30
	(1.73)	(2.10)	(2.52)	(1.16)
4	11.90	2.80	12.30	2.30
	(1.70)	(0.92)	(1.92)	(1.70)
5	12.00	2.45	12.35	3.00
	(1.83)	(1.28)	(1.80)	(0.85)

Week X Day (2 X 5) repeated measures ANOVAs conducted on physiological measures (oxygen consumption, ventilation, respiratory exchange ratio, heart rate, total caloric intake, carbohydrate, fat, and protein intake) revealed no significant day effects or week X day interactions.

Thus, the results of the daily analyses revealed that several of the measures changed over days. In general, mood became more positive and less negative over successive days of training, especially after Day 2. Overall, results of daily analyses suggest that changes in mood occurred gradually and that runners probably did not experience excessive psychological or physiological stress during the increased training as compared to the baseline training.

Retrospective Changes in Mood

On Day 5 of the normal training week and Day 5 (Day 10) of the increased training week, participants completed the PANAS, ISP, Affect Grid, and POMS responding to how they have felt "during the past week", prior to running. Table 13 presents means, standard deviations, F-ratios, and effect sizes for retrospective weekly responses.

Table 13

Means, Standard Deviations, F-ratios, and Effect Sizes for Retrospective Weekly Psychological Responses

	Baseline Training		Increased Training			
Measure	*M*	*SD*	*M*	*SD*	*F*	*ES*
POMS						
TMD	106.73	23.29	101.18	14.61	1.87	.16
Tension	7.36	5.99	5.00	2.05	3.13	.24
Depression	3.46	4.76	2.09	2.63	2.16	.18
Anger	3.09	5.09	1.46	1.97	2.76	.22
Vigor	18.64	4.11	17.00	7.14	1.40	.12
Fatigue	5.64	5.14	5.09	4.06	1.22	.11
Confusion	5.82	4.60	4.55	3.01	1.51	.13
ISP						
TMD	10.91	3.70	9.55	2.42	5.31*	.35
PANAS						
Positive	34.36	6.82	31.64	6.74	8.88*	.47
Negative	13.36	4.11	11.55	2.12	5.71*	.36
Affect Grid						
Pleas	6.46	1.51	6.46	.93	.00	.00
Arous	6.27	1.27	6.27	1.42	.00	.00

*$p < .05$

A series of repeated measures ANOVAs were conducted on each of the psychological measures to examine whether psychological responses to how one felt "during the past week" of baseline training were similar to responses "during the past week" of increased training. Results revealed no significant week effects for any of the POMS subscales or total mood disturbance. There was a significant week effect for Incredibly Short POMS total mood disturbance, $F(1,10) = 5.31$, $p < .05$. Total mood disturbance during the baseline training week was greater than during the increased training week. Thus, mood became more positive during the increased training week.

A repeated measures ANOVA conducted on PANAS positive affect responses revealed a significant week effect, $F(1,10) = 8.88$, $p < .05$. Positive affect was greater during the normal training week than during the increased training week. A repeated measures ANOVA conducted on the PANAS negative affect scale revealed a significant week effect, $F(1,10) = 5.71$, $p < .05$. Negative affect was greater during the baseline training week than during increased training week. Thus, from PANAS results, affect became less positive and less negative during the increased training week. The decrease in positive affect is in contrast to results of averaged daily positive affect responses in which there was no weekly change. This finding might suggest that daily and retrospective mood and affective responses are influenced by different situations and that cumulative successive daily mood responses may or may not lead to the same weekly mood response.

There were no significant week effects for Affect Grid pleasure and arousal responses.

In general, results of the retrospective weekly responses indicate mood improvement from the normal training to increased training week. With the exception of a decrease in PANAS positive affect, results of retrospective mood responses analyses support findings previously reported in the analysis of averaged weekly psychological responses.

CHAPTER V

DISCUSSION

The main purpose of this exploratory investigation was to examine whether psychological and physiological responses during a period of normal baseline training are similar to psychological and physiological changes during increased training conducted at the same intensity as the baseline training. Several studies (Costill, Bowers, Branam, & Sparks, 1971; Davenport, Flynn, Pizza, Wilkins, & Naeurth, 1992; Morgan, Costill, Flynn, Raglin, & O'Connor, 1988; Morgan, Costill, Kirwan, Raglin, & O'Connor, 1988; O'Connor, Morgan, & Raglin, 1991) have examined psychological and physiological responses to a period of increased training; however, previous studies are limited due to lack of a control, baseline normal training phase and reliance on one primary instrument to assess mood, the Profile of Mood States (POMS). Thus, this study attempted to extend previous research by monitoring psychological and physiological responses during a period of normal baseline and increased training and by examining mood and affect from a more conceptual approach. Specifically, positive and negative dimensions of mood/affect as well as pleasure and arousal dimensions of mood/affect were monitored over five days of normal training and five days of increased training. The Profile of Mood States (POMS) (McNair, Lorr, & Droppleman, 1971), Incredibly Short POMS (Dean, Whelan, & Meyers, 1990), Affect Grid (Russell, Weiss, & Mendelsohn, 1989), Positive and Negative Affect Scale (PANAS) (Watson, Clark, & Tellegen, 1988), and Feeling Scale (FS) (Hardy & Rejeski, 1989) were used to assess affective responses to exercise.

Weekly, daily, and temporal changes in psychological and physiological responses were examined. Additionally, a retrospective measure of mood, assessed at the end of the normal and increased training week was compared to a weekly measure of mood, formed by averaging responses to daily mood measures. Due to the exploratory nature of the study, directional hypotheses were not proposed; instead exploratory questions were proposed and examined.

The first question examined whether psychological responses during a week of normal training and week of increased training are similar. To answer this question, daily mood assessments collected before and after running each day as well as twice during runs, were averaged across days (5 days of normal training, 5 days of increased training) and time to form a composite mood score for the week. Results revealed changes in mood and affect across the two weeks. Tension/anxiety, depression, anger, and confusion subscales of the Profile of Mood States were lower during the week of increased training. Additionally, total mood disturbance, a composite measure of mood formed by adding the negative POMS subscales, subtracting the vigor score and adding a constant of 100, was lower during the week of increased training. The lower total mood disturbance score indicates that mood was more positive during the week of increased training than normal training. Negative affect assessed by the PANAS was also lower during the week of increased training. There was no significant change in PANAS positive affect from the normal training to increased training week.

Several studies have reported mood improvements following acute and chronic exercise. However, this study is unique in that affective states were examined both during a baseline normal training period and increased training period. Results of the weekly analysis suggest that compared to the normal training week, mood became more positive and less negative during the week of increased training. This finding is inconsistent with results of previous studies reporting mood disturbances during periods of increased training (Morgan, Brown, Raglin, O'Connor, Ellickson, 1987; Morgan, Costill, Flynn, Raglin,

& O'Connor, 1988; Morgan, Costill, Kirwan, Raglin, & O'Connor, 1988; O'Connor, Morgan, & Raglin, 1991). With the exception of Morgan, Costill, Kirwan, Raglin, and O'Connor (1988), previous studies have examined psychological and physiological responses to increased training in swimmers, thus generalizability to runners may be limited. Another possibility is that five days of increased training may be too short a period to produce mood disturbances. However, mood disturbances have been found after three days of increased training (O'Connor, Morgan, & Raglin, 1991), five days of increased training (Morgan, Costill, Kirwan, Raglin, & O'Connor, 1988), and ten days of increased training (Morgan, Costill, Flynn, Raglin, & O'Connor, 1988).

Results of this study are consistent with results reported by Davenport, Flynn, Pizza, Wilkins, and Naeurth (1992), who examined psychological responses of runners to ten days of increased training. Runners completed a month of normal training followed by 10-days of increased training either by doubling running volume or by cross training with running and cycling to increase training volume. Each of the increased training periods was preceded by two weeks of reduced training. Davenport et al. (1992) reported reductions in tension and depression subscales of the POMS after 5 days of increased training. The present results are consistent with those of Davenport et al. (1992) but also indicate decreases in anger, confusion, and total mood disturbance. The present study differs from Davenport et al. (1992) in that training volume was only increased 1.5 times normal distance rather than double normal training distance, although training intensity was similar (approximately 70% - 75% $\dot{V}O_2max$). The increase in training volume, duration, and intensity (approximately 70% - 75% $\dot{V}O_2max$) of the current study is similar to the increased training period used by Morgan, Costill, Kirwan, Raglin, and O'Connor (1988). Thus, whether increased training is associated with mood improvements or mood disturbances may depend on the mode, intensity, duration, and volume of training as well as instruments used to assess changes in mood.

Differences in subject fitness levels may also influence whether increased training is associated with mood improvements or mood disturbances. Subjects in the present study were considered moderately trained ($\underline{M}$ $\dot{V}O_2max$ = 51.7 $ml \cdot kg^{\cdot -1} min^{-1}$), while subjects in Costill et al.'s (1988) study were highly trained swimmers ($\underline{M}$ $\dot{V}O_2max$ = 4.62 $l \cdot min^{-1}$), and highly trained runners in Kirwan et al.'s (1988) study ($\underline{M}$ $\dot{V}O_2max$ = 67.6 $ml \cdot kg^{\cdot -1} min^{-1}$) and Davenport et al.'s (1992) study

($\underline{M}$ $\dot{V}O_2max$ = 65.1 ml·kg·$^{-1}$min^{-1}).

Another possible factor influencing mood is dietary intake. Athletes report greater tension, depression, anger, and total mood disturbance and less vigor on low carbohydrate (25% of total kilocalories) diets compared to moderate (50% of total kilocalories) and high carbohydrate diets (75% of total kilocalories) (Keith, O'Keefe, Blessing, & Wilson, 1991; Morgan, Costill, Flynn, Raglin, and O'Connor; 1988). However, it is unlikely that CHO intake influenced mood states in the present study because dietary intake, total energy intake, carbohydrate intake, fat intake, and protein intake were similar during the baseline and increased training week. Additionally, Morgan, Costill, Kirwan, Raglin, and O'Connor (1988) found that reduced carbohydrate or adequate carbohydrate diets during 5-days of increased training had no significant effect on mood. Morgan et al. (1988) found mood disturbances as a result of the increased training rather than diet. Thus, it is unlikely that diet influenced mood states in the present study as carbohydrate intake was at a moderate level each week, and the influence of diet on mood during increased training appears to be minimal.

It is also unlikely that the setting of the experiment influenced mood and affect changes associated with the increased training. In order to minimize fluctuation in moods due to diurnal variation, subjects completed testing at approximately the same time of day during both weeks of training. Additionally, the laboratory testing environment was kept constant (e.g., lighting, temperature, experimenter-subject interaction) during the course of the study.

A possible explanation for mood improvement rather than mood disturbance during the increased training week may be that participants were efficacious about their ability to complete the increased training. Bandura's (1977, 1986) self-efficacy theory states that an individual's beliefs regarding his/her capabilities may influence choice of activity, effort expenditure, and persistence. Additionally, efficacy cognitions influence thought processes and affective reactions. Therefore, runners in this study may have viewed the increased training in a positive manner, developed increased competence and positive feelings about their accomplishments, which in turn led to more positive mood and affect.

Another possible explanation for mood improvement during the increased training week may be due a sense of accomplishment associated with nearing the completion of the study and meeting the demands of the increased training load. Anecdotally, several runners expressed concern about their ability to complete successive running bouts during the increased training week but not during the baseline training week. Therefore, each session completed during the increased training week may have increased feelings of efficacy, and personal accomplishment and subsequently enhanced mood.

Although this study found mood improvements during the increased training week, methodologically other designs may help determine if mood improvement was actually due to the increased training. Future studies might employ a counterbalanced order design in which some subjects complete the baseline training followed by increased training and other subjects complete the increased training then baseline training. Another possible design would be a reversal design, baseline training - increased training - baseline training. Either the reversal or counterbalanced design would allow one to determine if mood improvement is associated with increased training or other alternative explanations (e.g., relief due to completion of study, habituation to setting).

Physiologically, minute ventilations ($l \cdot min^{-1}$) increased from normal training to increased training. The increase in ventilation may be due to increased core temperature, increased blood lactate concentration, or increased norepinephrine to epinephrine concentration. Each of these physiological changes, associated with prolonged exercise, would stimulate an increase in ventilation (Astrand & Rodahl, 1986). There were no significant changes in any of the other physiological measures.

The physiological measures examined in this study (i.e., $\dot{V}O_2$, HR, V_E, RER) were selected because they can reflect increases in fatigue and have been shown to change with increased training (Kuipers, Verstappen, Keizer, Geurten & VanKranenburg, 1985). Although there were no significant changes in heart rate, oxygen consumption, or respiratory exchange ratios between the normal and increased training week, other parameters not measured may have reflected physiological distress associated with increased training (e.g., muscle glycogen concentrations, creatine kinase concentrations, blood lactate concentrations) (Costill, Flynn, Kirwan, Houmard, Mitchell, Thomas, & Han Park, 1988; Kirwan, Costill, Flynn, Mitchell, Fink, Neufer, & Houmard, 1988; Kirwan, Costill, Mitchell, Houmard, Flynn, Fink, & Beltz, 1988). Furthermore, with no changes in the physiological measures examined, it is likely that the psychological changes observed were due to reasons other than physiological change. However, physiologically, the study is limited due to the parameters measured and because $\dot{V}O_2max$ was not reassessed after increased training. Changes in $\dot{V}O_2max$ would suggest that the runners were doing less relative work during the increased training week compared to the baseline training week. Thus, psychological changes (e.g., mood improvement) could possibly be associated with changes in fitness.

Results of weekly psychological and physiological responses suggest that runners in the present study were neither physically nor psychologically stressed by the period of increased training to a greater extent than the baseline training. In this study, physiological changes were not expected between the two weeks, because intensity was kept constant. Thus, psychological changes associated with the increased training were probably not due to physiological changes. Future studies might attempt to examine associations between psychological and physiological changes by examining other physiological parameters (e.g., blood lactate concentrations, muscle glycogen concentrations) and manipulating increased training by varying intensity or volume of training. Future studies might also examine the associations between self-efficacy, affect, and training.

The first and second research questions examined psychological and physiological responses to chronic or successive bouts of exercise. The next two research questions examined daily and temporal responses to exercise sessions, and thus focus on responses to acute bouts of exercise. Several studies have examined affective responses to single bouts of exercise (e.g., Markoff, Ryan, & Young, 1982; Kraemer, Dzewaltowski, Blair, Rinehardt, & Castracane, 1990; Steptoe & Cox, 1988). In general studies examining affective responses to acute single bouts of exercise reveal that exercise of sufficient duration (i.e., at least 20 min) and intensity (i.e., at least 70% $\dot{V}O_2max$) is associated with mood improvements (Petruzzello & Landers, 1991).

To examine temporal changes in affect, responses to psychological measures were averaged over days and a weekly time score computed for each collection time during the normal training and increased training week. Results revealed that confusion and depression subscales of the POMS and total mood disturbance, were all lower after single bouts of running during both the normal and increased training weeks. Total mood disturbance assessed by the Incredibly Short POMS also tended to decrease over time as the second collection during the run was lower than the measure assessed before the run. Positive affect assessed by the PANAS prior to the run was lower than positive affect after the run and negative affect decreased over the course of the run. Additionally, pleasantness and arousal dimensions of affect assessed by the Affect Grid increased during single bouts of exercise. Thus, even though perception of effort increased during single running sessions it appears that affective responses to exercise became more positive and less negative. Furthermore, affect improved across time during both the normal training and increased training week. The positive affective changes in response to acute bouts of exercise are consistent with previous research and support the conclusion of Petruzzello and Landers (1991) that exercise for at least 20 minutes conducted at an intensity of at least 70% $\dot{V}O_2max$ or 70% age adjusted HRmax is associated with improved mood.

Temporal changes in physiological responses revealed that oxygen uptake, minute ventilation, and heart rate increased from the first collection time to second collection time, representing normal responses to prolonged bouts of aerobic exercise. The slight increase in oxygen consumption, heart rate, and minute ventilation may be responses to increases in body temperature as a result of the prolonged exercise or an increase in use of free fatty acids as an energy substrate (Astrand & Rodahl, 1986). Although there was no significant change in the respiratory exchange ratio, which would support increased utilization of free fatty acids, the respiratory exchange ratio decreased slightly during exercise sessions. This slight decrease indicates a change in substrate utilization from carbohydrates to free fatty acids.

In terms of daily changes in psychological and physiological responses, compared to the first day of training, several measures were different on the second day of normal training (e.g., tension/anxiety, negative affect, Affect Grid arousal). The changes in psychological responses during the second day of training each week indicated slight trends towards more negative mood states. However, this trend did not continue as mood during the week of increased training improved over the baseline training week, and in general mood was rather positive.

The final analyses examined weekly changes in mood using retrospective rather than daily mood responses. Prior to running, on the last day of both the baseline training week and increased training week, participants completed the psychological inventories according to how they felt during the past week. Results revealed no significant weekly changes in any of the POMS subscales or total mood disturbance. Incredibly Short POMS total mood disturbance decreased from the baseline training to increased training week, indicating that mood became more positive during the increased training week. Additionally, affect became less positive and less negative during the week of increased training (PANAS).

The retrospective changes in mood are weaker but consistent with the averaged weekly responses previously reported. Retrospectively, there were fewer significant changes in mood, yet overall results support less negative and slightly more positive (i.e., total mood disturbance) mood during the week of increased training. The differences between the averaged weekly responses and retrospective weekly responses may be influenced by time. The averaged weekly responses were based on responses collected at that moment, whereas retrospective measures were based on the past week. It is possible that factors and situations other than the training may have influenced restrospective responses to a greater extent than daily moment responses.

The present study examined psychological responses during a period of baseline and increased training from a more conceptual basis (e.g., positive and negative dimensions of affect) than previous studies. It appears that the Profile of Mood States, Incredibly Short Profile of Mood States, Positive and Negative Affect Schedule, Affect Grid, and Feeling Scale are effective inventories for assessing mood and affective states prior to, during, and after exercise.

The Profile of Mood States, although too cumbersome to administer during exercise, appears to be a useful inventory for mood assessment prior to or after exercise. The POMS is also moderately related to other instruments assessing both positive and negative and pleasure and arousal dimensions of mood. The PANAS allows for the assessment of mood states prior to and after exercise as well as during exercise. Additionally, the PANAS is useful for assessing both positive and negative mood states to a greater extent than the POMS. Both the POMS and PANAS were useful instruments for measuring changes in mood in this study. The ISP, Affect Grid, and Feeling Scale were not as effective in measuring psychological changes between the two weeks of training.

Interestingly, the POMS revealed changes in mood for "moment" responses rather than "week" responses, which validation for the POMS is based upon. The Incredibly Short Profile of Mood States was not as effective as the POMS for assessing changes in mood between the two weeks of training. Like the ISP, Affect Grid responses did not differ between baseline and increased training, however, both pleasure and arousal dimensions increased similarly over the days of training.

Although the PANAS and Affect Grid have not been widely used in sport and exercise psychology, these inventories have been validated with undergraduate and nonstudent adult populations and allow for the assessment of positive and negative, and pleasure and arousal dimensions of mood and affect. Because the inventories permit assessment of affect during exercise, future studies might be able to determine how often and when affect needs to be assessed during exercise sessions. Furthermore, approaching the study of mood/affect and exercise from a more conceptual level may lead to the development of sport and exercise-specific affective inventories. Thus, it is recommended that future studies continue to use the POMS and further examine mood and affective responses with the PANAS and Affect Grid.

In conclusion, results of this study suggest that a five-day period of increased training in runners does not result in mood disturbances or physiological stress to a greater extent than five days of baseline training Physiologically, future studies should attempt to examine other physiological parameters (e.g., lactates, glycogen concentrations), different training protocols (e.g., increased intensity), and the influence of increased training on performance. Psychologically, the instruments used in this study to assess mood and affect need further use in exercise settings. The PANAS and Affect Grid appear useful for examining mood and affect during exercise sessions due to their ease of administration, possible elimination of response bias, and conceptual basis. In addition to further use of these inventories, future studies might examine associations between efficacy attributions, affective responses and exercise, and associations between physiological and psychological responses to exercise; as these studies might lead to a better understanding of exercise participation, adherence, and well-being associated with exercise.

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Appendix F

Profile of Mood States

Appendix K

Psychological Data

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 /2  PRE1M41 TO PRE1M65 4-28 RPE1A 30-31 FS1A 32-33 ROW1A
     34 COL1A 35 P1A1 TO P1A20 37-56 ISP1A1 TO ISP1A6 58-63
 /3  RPE1B 4-5 FS1B 6-7 ROW1B 8 COL1B 9 P1B1 TO P1B20 11-30
     ISP1B1 TO ISP1B6 32-37 PO1P1 TO PO1P20 39-58 PO1SP1 TO
     PO1SP6 60-65 PO1ROW 67 PO1COL 68
 /4  PO1M1 TO PO1M65 4-68
 /5  PRE2P1 TO PRE2P20 4-23 PRE2SP1 TO PRE2SP6 25-30
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 /6  PRE2M41 TO PRE2M65 4-28 RPE2A 30-31 FS2A 32-33 ROW2A
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Appendix L

Physiological Data

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     HR1B 58-60
 /2  WT2 4-8 (2) VO22A 9-12 (2) O22A 13-15 (2) RE2A 16-18
     (2) HR2A 19-21 VO22B 23-26 (2) O22B 42-45 (2) RE2B
     30-32 (2) HR2B 33-35 WT3 37-41 (2) VO23A 42-45 (2)
     O23A 46-48 (2) RE3A 49-51 (2) HR3A 52-54 VO23B 56-59
     (2) O23B 60-62 (2) RE3B 63-65 (2) HR3B 66-68
 /3  WT4 4-8 (2) VO24A 9-12 (2) O24A 13-15 (2) RE4A 16-18
     (2) HR4A 19-21 VO24B 23-26 (2) O24B 42-45 (2) RE4B
     30-32 (2) HR4B 33-35 WT5 37-41 (2) VO25A 42-45 (2)
     O25A 46-48 (2) RE5A 49-51 (2) HR5A 52-54 VO25B 56-59
     (2) O25B 60-62 (2) RE5B 63-65 (2) HR5B 66-68
 /4  WT6 4-8 (2) VO26A 9-12 (2) O26A 13-15 (2) RE6A 16-18
     (2) HR6A 19-21 VO26B 23-26 (2) O26B 42-45 (2) RE6B
     30-32 (2) HR6B 33-35 WT7 37-41 (2) VO27A 42-45 (2)
     O27A 46-48 (2) RE7A 49-51 (2) HR7A 52-54 VO27B 56-59
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 /5  WT8 4-8 (2) VO28A 9-12 (2) O28A 13-15 (2) RE8A 16-18
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     30-32 (2) HR8B 33-35 WT9 37-41 (2) VO29A 42-45 (2)
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     (2) O29B 60-62 (2) RE9B 63-65 (2) HR9B 66-68
 /6  WTX 4-8 (2) VO2XA 9-12 (2) O2XA 13-15 (2) REXA 16-18
     (2) HRXA 19-21 VO2XB 23-26 (2) O2XB 42-45 (2) REXB
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     VENT2B 17-20 (2) VENT3A 22-25 (2) VENT3B 26-29 (2)
     VENT4A 31-34 (2) VENT4B 35-38 (2) VENT5A 40-43 (2)
     VENT5B 44-47 (2) VENT6A 49-52 (2) VENT6B 53-56 (2)
     VENT7A 58-61 (2) VENT7B 62-65 (2)
 /8  VENT8A 4-7 (2) VENT8B 8-11 (2) VENT9A 13-16 (2)
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    PROT8 30-31 CHO8 32-33 FAT8 34-35 KCAL9 37-40
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