THE MAGNITUDE OF THE A AND B PROCESSES FROM THE OPPONENT
PROCESS THEORY FOR MODERATE AND HIGH INTENSITIES IN SEDENTARY
DEPRESSED WOMEN

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the Graduate

School of the Ohio State University

By

Maria I. Rozorea, M.A.

The Ohio State University
2007

Dissertation Committee:

Professor Janet Buckworth, Advisor

Professor Brian Focht

Professor Paul Granello

Approved by

Advisor
College of Education and
Human Ecology
ABSTRACT

The purpose of this study was to investigate the relationship between a and b processes from the Opponent Process Theory: specifically, the study is designed to examine if a more pronounced negative affective response during an acute exercise session (a process) generates a stronger and longer lasting improvement post-exercise (b process) when equating for the total energy expenditure in sedentary depressed women. Also, a secondary purpose was to investigate whether participants would pick the intensity that corresponds with higher and longer lasting positive affect (e.g. increased pleasure, enjoyment) after exercise.

The results indicated that the primary purpose to test the OPT was supported. Higher intensity exercise bouts were associated with higher magnitude (both negative, during a-process and positive, during b-process) and longer lasting response (pleasure) post exercise compared to a bout of moderate intensity exercise. This result is important in the context of exercise prescriptions as higher intensities (above a certain threshold) are associated with significantly greater changes in positive affect post exercise. Finally, the secondary purpose was partially supported, as depressed women selected intensities, at a third exercise session, associated with exercise enjoyment recalled post exercise but not associated with the greater increase in pleasure post exercise.
ACKNOWLEDGMENTS

I wish to thank my advisor, Dr. Janet Buckworth, for her constant help and guidance. Her support and encouragement came always at the right time. She is the best advisor and teacher I could have wished for.

I would like to thank Dr. Paul Granello and Dr. Brian Focht for their help and I am grateful to them for making the time to meet with me whenever it was necessary and for providing essential feedback on this project. I would especially like to thank Dr. Focht for providing incentives for the participants.

I also thank all of the participants for their excellent attitude and for being in this study.

I want to thank all my family for their efforts in bringing me where I am today and for all the help they have given me thought the years.

I would like to thank my husband, George, for his constant love, support, patience and understanding.

And finally, I would like to thank Elena, my 5 months daughter for being part of my life!
VITA

August 3rd, 1978……… Born in Bucharest, Romania

2002………………… B.S. National Academy of Physical Education and Sport
Specialization: Physical Therapy

2005………………...M.A in Exercise Science, The Ohio State University

2002-Present…………Graduate Teaching Assistant,
The Ohio State University

PUBLICATIONS

Research Publication


FIELDS OF STUDY

Major Field: College of Education and Human Ecology
TABLE OF CONTENTS

Abstract........................................................................................................................................ ii

Acknowledgments ...................................................................................................................... iii

Vita................................................................................................................................................ iv

List of Tables ................................................................................................................................ viii

List of Figures ............................................................................................................................ x

Chapter 1....................................................................................................................................... 1
  Purpose of the study.................................................................................................................. 7
  Definition of Terms................................................................................................................. 11
  Assumptions............................................................................................................................. 14
  Delimitations of the Study .................................................................................................... 14

Chapter 2....................................................................................................................................... 15
  Introduction.............................................................................................................................. 15
  Depression............................................................................................................................... 15
  Exercise and Mental Health................................................................................................. 19
  Exercise Parameters............................................................................................................. 23
  Prescribed versus Preferred Intensity.................................................................................. 43
  Theory and Hypothesized Mechanism................................................................................ 48
    Opponent Process Theory................................................................................................. 48
    Hypothesized Mechanisms............................................................................................... 53
  Summary................................................................................................................................. 58

Chapter 3....................................................................................................................................... 60
  Study Design.......................................................................................................................... 60
  Selection of Participants....................................................................................................... 61
  Assessment Measures.......................................................................................................... 64
    Maximal Oxygen Consumption......................................................................................... 64
    Exercise Intensity.............................................................................................................. 65
    Ratings of Perceived Exertion......................................................................................... 68
    Psychological Measures.................................................................................................... 68
    Self-Assessment Manikin................................................................................................. 70
    Enjoyment.......................................................................................................................... 71
    Self-Efficacy....................................................................................................................... 72
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 3.1</td>
<td>Time measurements for SAM, PAES and Self Efficacy</td>
<td>70</td>
</tr>
<tr>
<td>Table 4.1</td>
<td>Descriptive statistics for the study group</td>
<td>78</td>
</tr>
<tr>
<td>Table 4.2</td>
<td>Mean and Standard Deviation for SAM Pleasure during a-process</td>
<td>79</td>
</tr>
<tr>
<td>Table 4.3</td>
<td>Mean and Standard Deviation of SAM change scores from Moderate to High Intensity (a-process)</td>
<td>81</td>
</tr>
<tr>
<td>Table 4.4</td>
<td>Mean and Standard Deviation of SAM change scores for Moderate Intensity (a-process)</td>
<td>82</td>
</tr>
<tr>
<td>Table 4.5</td>
<td>Mean and Standard Deviation of SAM change scores for High Intensity (a-process)</td>
<td>83</td>
</tr>
<tr>
<td>Table 4.6</td>
<td>Mean and Standard Deviation for SAM Arousal during a-process</td>
<td>84</td>
</tr>
<tr>
<td>Table 4.7</td>
<td>Mean and Standard Deviation for SAM Dominance during a-process</td>
<td>87</td>
</tr>
<tr>
<td>Table 4.8</td>
<td>Mean and Standard Deviation for SAM Pleasure during b-process</td>
<td>90</td>
</tr>
<tr>
<td>Table 4.9</td>
<td>Mean and Standard Deviation of the difference in SAM change scores from Moderate to High Intensity (b-process)</td>
<td>91</td>
</tr>
<tr>
<td>Table 4.10</td>
<td>Mean and Standard Deviation of SAM change scores for Moderate Intensity (b-process)</td>
<td>92</td>
</tr>
<tr>
<td>Table 4.11</td>
<td>Mean and Standard Deviation of SAM change scores for High Intensity (b-process)</td>
<td>93</td>
</tr>
</tbody>
</table>
Table 4.12  Mean and Standard Deviation for SAM Arousal during b-process.................................................................94
Table 4.13  Mean and Standard Deviation for SAM Dominance during b-process.................................................................96
Table 4.14  Classification Table Choice.........................................................103
Table 4.15  Mean and Standard Deviation for Enjoyment during b-process.................................................................104
Table 4.16  Mean and Standard Deviation for Average Self-Efficacy at pre-test, 5, 15 and 30 minutes post test..............................105
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1</td>
<td>Model for Primary Aim</td>
</tr>
<tr>
<td>Figure 3.1</td>
<td>Bruce Treadmill Protocol</td>
</tr>
<tr>
<td>Figure 3.2</td>
<td>Speed on treadmill as a function of VO₂</td>
</tr>
<tr>
<td>Figure 3.3</td>
<td>Grade on treadmill as a function of VO₂</td>
</tr>
<tr>
<td>Figure 4.1</td>
<td>Change scores for SAM Pleasure during a-process</td>
</tr>
<tr>
<td>Figure 4.2</td>
<td>Change scores for SAM Arousal during a-process</td>
</tr>
<tr>
<td>Figure 4.3</td>
<td>Change scores for SAM Dominance during a-process</td>
</tr>
<tr>
<td>Figure 4.4</td>
<td>Change scores for SAM Pleasure during b-process</td>
</tr>
<tr>
<td>Figure 4.5</td>
<td>Change scores for SAM Arousal during b-process</td>
</tr>
<tr>
<td>Figure 4.6</td>
<td>Change scores for SAM Dominance during b-process</td>
</tr>
<tr>
<td>Figure 4.7</td>
<td>Pleasure Mean Score by Intensity over Time</td>
</tr>
<tr>
<td>Figure 4.8</td>
<td>Arousal Mean Score by Intensity over Time</td>
</tr>
<tr>
<td>Figure 5.1</td>
<td>Pleasure and Arousal at four Measurement Points</td>
</tr>
</tbody>
</table>

Page numbers: 9, 64, 67, 67, 83, 86, 89, 94, 96, 98, 99, 100, 101, 148
CHAPTER 1
INTRODUCTION

The benefits from regular physical activity and exercise have both a physical and a psychological component (Morgan, 1997). Epidemiological and clinical studies suggest that exercise reduces the risk of developing several physical and mental diseases, including coronary artery disease (Blair et al., 1996), non-insulin-dependent diabetes (Helmsich, Ragland, Leung, & Paffenbarger, 1991), hypertension (Tipton, 1991), and depression (Blumenthal, et al., 1999; Paffenbarger, Jr., Lee, & Leung, 1994). However, fewer than one in three Americans meet the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) recommendation to engage in 30 min or more of moderate-intensity physical activity on most, preferably all days of the week (Jones et al., 1998). In addition, women are less likely to be physically active than men (Healthy People 2010 Update, 2000).

With more than 50% of individuals dropping out of an exercise program within the first six months (Dishman, 2001) it is important to examine factors such as the intensity of exercise that may influence the high dropout rate among exercise participants and poor adherence to exercise programs. Several studies supported the idea that higher intensity is associated with lower adherence (Lee et al., 1996), however in a review from 1999, Ekkekakis and Petruzzello acknowledged that there is not enough research to
confirm that lower doses of activity are more enjoyable. Moreover, a few studies showed that high intensity exercise compared with other types of intensities might actually be a better alternative for significant reductions in state anxiety (Cox, Thomas, Hinton, & Donahue, 2004), psychotherapeutic effects (Hays, 1999), general psychotherapeutic benefits (Kirkcaldy & Shepherd, 1990), and mood enhancement (Berger & Motl, 2000).

Regardless of the intensity (high, medium, low, preferred, prescribed, etc), regular physical activity or bouts of exercise are associated with positive effects on mood. Whether these positive effects last for a long or a short amount of time is probably a function of many variables, including the intensity of the exercise session and the exercise history of the individual. Even demographic variables like age, gender, marital status could possibly be predictors of affect metrics, such as magnitude and duration. While the correlation between exercise and positive affect is accepted by most researchers, the mechanism that regulates this correlation is not very well understood. In this sense, there is a clear need for theories to explain this relationship.

Depression is a mood disorder that can create symptoms that can interfere with the ability to function, being a common and important cause of morbidity and mortality worldwide (Murray et. al., 1997). The costs to society are enormous in terms of both suffering and economics. According to the World Health Organization’s Global Burden of Disease Study (Üstün et al., 2004), depression is the leading cause of disability in the world, and the 4th leading cause of disease burden. It is the leading cause of total
disability adjusted life-years for women, and the 4th leading cause for men. It is estimated that the cost of major depression alone in the U.S is more than $80 billion dollars per year (Zunkel, 2003).

Depression is a major health problem and women are two times more likely than men to be affected by depression (Wilhelm, Parker, & Hadzi-Pavlovic, 1997). The highest rates of depression are seen in women of reproductive age (Stewart, Gucciardi & Grace, 2004). Although there is no scientific explanation for the increased risk of depression among women, it is believed that the cause is a combination of genetic, environmental, psychological and hormonal factors. Women also more frequently develop symptoms of anxiety, panic, phobia, eating disorders and dependent personality and they also have a higher incidence of hypothyroidism, a condition that can cause depression (Weissman & Klerman, 1977).

Each year, about 30,000 people die by suicide in the United States (Institute of Medicine, 2002). Many more attempt suicide. More than 90% of the people who commit suicide suffer from some form of mental disorder, such as depression (Moscicki, 2001).

Depression often remains inadequately treated. Only 40.2% of employed individuals and 32.9% of unemployed individuals suffering from depression seek professional treatment, although effective pharmacological interventions are available (Greenberg, 2003). The compliance with the treatment is poor, as 20% to 59% of individuals stop taking their antidepressant medication within 3 weeks of the prescription.
date (Lawlor, 2001). This is especially unfortunate because it takes weeks until one sees
the benefits of the pharmacological treatments (O’Neal, Dunn, Martinsen, 2000). These
treatments could be accompanied by severe side effects, like cardiovascular
complications and addiction (Buckworth & Dishman, 2002), and many of the
pharmacological treatments produce weight gain (Stunkard, Faith, & Allison, 2003).

Multiple studies reported that physical activity can reduce the severity of
symptoms in depressed patients (Craft, 1997). Some data suggest that even a single
exercise bout may result in a substantial mood improvement (Dimeo, 2001), thus exercise
may be a desirable alternative or adjunct treatment.

Depression is a serious problem, and women are more likely to be affected.
Physical activity can be useful in prevention and treatment of depression, but according
to Centers for Disease Control and Prevention (CDC), women are less likely to be
physically active than are men. Depressed women can benefit from regular exercise, but
like most adults, are at risk of dropping out of an exercise program.

In light of these barriers, it is important to determine the parameters surrounding
an exercise session that are associated with the greatest psychological well-being, and
positive affects. In terms of intensity, multiple studies (Dishman, 1986; Kirkcaldy &
Shepherd, 1990; Raglin & Morgan, 1985) have shown that the exercise intensity must
exceed a certain “threshold” in order for the bout of exercise to produce significant
psychological benefits. This possible threshold level at a higher exercise intensity
necessary to trigger the positive psychological benefits tends to be against the current public health recommendations to accumulate moderate intensity physical activity, which is more accommodating and less demanding. On the other hand, more recent studies (e.g., Ekkekakis & Petruzzello, 1999) show little support for the ‘threshold’ assumption by showing that moderate intensity is just as beneficial as the high intensity for affective responses.

The evidence for a specific intensity to improve mood is mixed, and exercise levels associated with improvements in mental health have not yet been established (Dunn, Trivedi, & O'Neal, 2001). However, the CDC/ACSM recommendations, in terms of the weekly energy expenditures, have been associated with a significant reduction in depression (Dunn, Trivedi, Kampert, Clark & Chambliss, 2005). More research is needed in this direction, especially trying to differentiate these parameters for classes of subjects, rather than defining fixed parameters for the entire population as a whole.

Although the relationship between exercise and psychological health is well known, the duration of the mood effect is not known. Studies have reported positive affective responses to last from 20 min (Reed, Berg, Latin, & La Voie, 1998), 30 min (Steptoe, Kearsley & Walters, 1993), 60 min (Cox, Thomas, Davis, 2001), 2 hours (Porcari, Ward, Morgan, 1988) and even up 24 hours (Maroulakis & Zervas, 1993) after exercise. Additional research is needed to determine the dose of acute exercise that produces the optimal, longest lasting improvement in psychological states. The time
interaction and the levels of affect change after exercise are important factors in understanding the complete value of exercise and in designing the most effective interventions for people who suffer with depression.

Besides the questions related to the duration of the effect, it is also important to know when the positive effect starts. The studies that were designed with repeated measurements of affect have shown that the improvement takes place as soon as the exercise is finished (Tate & Petruzzello, 1995). This pattern is consistent with the predictions of the Opponent Process Theory (OPT) of affect (Solomon, 1980), which states that after the termination of an exercise bout there is an improvement in affect, the so called b-process which is trying to bring the organism to a state of hedonic neutrality.

The OPT can be studied in the context of different types of stimuli, from the reaction to electric shocks to the emotions of skydivers jumping from planes (which was the original study upon which the theory was developed). We believe that applying the OPT to exercise as the stimulus can reveal important information about mood effects from acute exercise. In this case, the theory would suggest that while exercising, people are in general affected by negative emotions associated with the physical effort or even pain. Immediately after the exercise session ends, the negative affective responses are reversed and are replaced by positive emotions like pleasure, satisfaction or sense of accomplishment. The opponent process tends to bring the organism into equilibrium. How long this process lasts, the magnitude of the emotions associated with it, and the
time it takes the organism to return to the equilibrium (e.g., pre-stimulus) state are important questions to answer when evaluating the benefits of the exercise stimulus.

A major limitation in testing this theory is the difficulty in measuring affect at various points in time, which are prior to, during and after acute exercise. Rather than looking at a static picture of affect, the measurements need to follow a flow of emotions and hence we’re dealing with a dynamic, continual process.

The American College of Sports Medicine (ACSM, 2000) recommends that, to gain health benefits, adults should try to accumulate 30 min or more of moderate-intensity exercise on a daily basis. These recommendations have been developed with individuals’ physiological health in mind (Daley & Maynard, 2003), but research that clarifies whether such health guidelines hold true for the psychological benefits associated with participation in exercise is still required.

PURPOSE OF THE STUDY

Information about the intensity required to elicit positive affective effects would be useful to exercise and health psychologists and other professionals involved with the promotion and prescription of exercise in depressed population. Therefore, the purpose of this study is to use the OPT to compare the affective response over time to single bouts
of moderate (standard health recommendations) and higher intensity aerobic exercise when equating for total energy expenditure in depressed sedentary women.

1. Primary Purpose:

To investigate the relationship between a and b processes from the Opponent Process Theory: specifically, the study is designed to examine if a more pronounced negative affective response during an acute exercise session (a process) generates a stronger and longer lasting improvement post-exercise (b process) when equating for the total energy expenditure in sedentary depressed women (see Figure 1.1). Note that the a-process is shorter for high intensity compared with moderate intensity (the time it takes one to expand 150 calories at high intensity is less than at moderate intensity).

Hypothesis to be tested:

A. During the exercise session, the negative affect has a higher magnitude for the higher intensity than for the moderate intensity.

B. After exercise, the positive affect reaches higher levels and it is longer lasting for the higher intensity than for the moderate intensity.
Figure 1.1 Model for primary aim.

The OPT predicts that the response magnitude is a function of the intensity of the stimulus, in the sense that the higher the intensity, the bigger the magnitude. During exercise, we expect participants will experience negative affect in response to the effort required by the exercise session (a-process). This negative affect should have a higher magnitude for the higher exercise intensity. As soon as the exercise session ends, the b-process takes over and we therefore expect the participants to experience a sharp change in affect, towards the positive scale. The change in affect continues for some time after the exercise session ends. The affective response after exercise will be a function of the exercise intensity. We expect that the positive affect following the higher exercise intensity session will last longer than the one following the moderate intensity session. Also, at some point after the end of each session we expect the affect metrics to cross
over, with the higher intensity positive affective response staying greater than the moderate response thereafter.

2. Secondary Purpose:

Participants will be asked to pick either the moderate or high intensity for their exercise intensity at a third exercise session.

Hypothesis to be tested:

Participants will pick the intensity for the third session that corresponds with higher and longer lasting positive affect (e.g. increased pleasure) after exercise.
DEFINITION OF TERMS

Acute exercise – A single session of exercise; typically short, but can last for one hour or more.

Acute exercise was defined as a single session of supervised moderate or higher intensity aerobic exercise on a motorized treadmill in which participants expended 150 Kcal through walking or jogging.

Affect – is the expression of value given to a feeling state. Affect could be described by three dimensions: pleasure-displeasure, excitement-calm, and strain-relaxation.

Affect was defined as response to Self Assessment Manikin (SAM) and Physical Activity Enjoyment Scale (PAES).

Arousal – a unidimensional state of physiological activation that runs on a continuum from sleep to extreme activation.

Arousal was defined as scores on the arousal subscale of SAM.

Body Mass Index (BMI) – A weight-for-height ratio widely used in epidemiological studies to categorize people according to their degree of obesity.

Weight in kilograms and height in meters were measured in the laboratory and the following formula was used to compute BMI: Wt (kg)/ht (m^2)

Depressive disorder - An illness that involves the body, mood, and thoughts. It affects the way a person eats and sleeps, the way one feels about oneself, and the way one thinks about things. A depressive disorder is not the same as a passing blue mood.
For this study, depressive symptoms were evaluated using Beck Depression Inventory. Only women with a current diagnosis of depression or who reported a mild to moderate depression on BDI questionnaire were included in the study.

Enjoyment – A particular form or source of pleasure

Enjoyment was defined as scores based on response to PAES.

Exercise – A subset of physical activity consisting of planned, structured, repetitive bodily movements with the purpose of improving or maintaining one or more components of physical fitness or health.

Exercise was defined as walking on the treadmill at a prescribed speed, grade and duration in order to expend 150 kcal.

Exercise Prescription – Recommendation for a specific exercise mode, intensity, duration and frequency per week to meet specific goals.

The participants had to exercise on a treadmill three times, during each session expending 150 kcal at a moderate and a high intensity.

Dominance - The disposition of an individual to assert control in dealing with others.

Dominance was defined as response to SAM.

Intensity – Refers to how much work is performed during exercise; expressed as an absolute quantity (e.g., watts) or relative to maximal capacity (e.g., 70% of maximal aerobic capacity), or as perception of effort (ratings of perceived exertion).
In this study, moderate intensity was defined as 40% of maximal aerobic capacity and high intensity was defined as 70% of maximal aerobic capacity.

**Mood** – Type of affective state that is accompanied by anticipation, even unconsciousness, of pleasure or pain; moods can last less than a minute or for days.

In this study mood was defined as responses to SAM.

**Physical Activity** – Any bodily movement produce by skeletal muscle that results in energy expenditure.

Physical activity was determined by responses to Exercise Stage of Change Questionnaires and Godin Leisure Time Questionnaires.

**Perceived exertion** – The subjective judgment of strain or effort during physical activity; a perception of quantity more than quality of sensations.

Perceived Exertion was defined as response to Borg’s 6-20 category scale.

**Pleasure** - The state or feeling of being pleased or gratified.

Pleasure was defined as response to SAM.

**Self-Efficacy** – Perception of one’s ability to carry out behavior with known outcome; Expectations of personal mastery regarding initiation and persistence of behavior.

Self-Efficacy was defined as participant’s confidence in being able to successfully expend 150 kcal at a moderate and a high intensity.
ASSUMPTIONS

1. The participants will be able to expend the 150 kcal at the moderate/high intensity.
2. The participants will understand and respond honestly to questions from all surveys.
3. The participants will have similar levels of fatigue and muscle soreness during each of the three experimental sessions.
4. Current personal life events will not influence individual responses to the exercise bouts.

DELIMITATIONS

1. The sample population was limited to adult women in Columbus, OH. All participants were women, between the ages of 18-50.
2. Exercise mode was walking/running on a treadmill.
3. Participants were experiencing self-reported symptoms of depression; eligibility for participation was not dependent on a clinical diagnosis of depression.
A literature review was conducted to provide a rationale and foundation for this research project. The following chapter begins with background information about the incidence and etiology of depression and characteristics of this mental disorder. We review the relationship between exercise and mental health and we continue with a discussion about various types of exercise intensities and their impact on different psychological variables. This chapter will conclude with a review of theories and hypothesized mechanisms through which physical activity triggers different mental health benefits. In particular, we discuss the impact of exercise intensity in terms of the Opponent Process Theory.

DEPRESSION

Depression is very serious health problem and according to the World Health Organization (WHO) ranks among the most disabling disorders, as an estimated 340 million people are affected worldwide (Zunkel, 2003). Depression is associated with long episodes of relapse, recurrence, psychosocial and physical disability with only 20% of
depressed individuals receiving effective treatment (Keller, 2001). On average, depressed individuals use two to four times more health care than people without a mental illness but the huge cost of depression is rather indirect, associated with disability and lost productivity at work. Depression has a 15% risk of death from suicide being one of the most underrecognized and undertreated illnesses in the world (Zunkel, 2003).

Depressive disorders are defined within the classification of Mood Disorders. Mood Disorders are broadly divided into Bipolar Disorders, which include Bipolar Disorder and Cyclothymia, and Depressive Disorders, which include Major Depression and Dysthymia. (American Psychiatric Association, 2000).

Among all diseases, major depression disorder ranks fourth in terms of disease burden and is the leading cause of disability in the market economies according to the World Health Organization’s Global Burden of Disease Study (Greden, 2001). At the present time, the disease burden from major depression is ahead of the one for diabetes, cerebrovascular disease, dementia and lung cancer (Murray & Lopez, 1996; Greden, 2001). According to World Health Organization (WHO), depression is one of the most disabling disorders (measured in disability-adjusted life years, or DALYs) in the world, affecting 340 million people worldwide. Major Depression is the fourth most important cause worldwide of loss in DALYs and by 2020 will be the second most important cause (Greden, 2001; National Institute of Mental Health [NIMH], 2002).
In the United States, approximately 12% of women and 6.6% of men will have a depressive disorder during one year (Greden, 2001). Also, 7.4% of adolescents report symptoms consistent with the diagnosis of major depression (Riolo et al., 2002).

A fairly recent study (Lobos, Scherer, Anderer & Katschnig, 2002) found that the female/male ratios of depression rates over the life cycle follow an inverted U-shape. The greatest ratio was found around the ages of 45-50, with a floor value of 1.5:1 for the extremes (young adulthood and ages around 60). Also, from the same study some interesting results were found regarding the marital status. The authors further analyzed the female/male ratio of depression curve for marital status and employment status, and found significant variations between different categories. For married people, the ratio was as high as 3:1, declining sharply after the age of 50. For the people not currently married the ratio declined after the age of 40 (from around 2.8:1 to 1:1 at the age of 50 and later). The study also looked at the relationship between affective disorders and employment status and showed that unemployment increases the risk for psychological disturbances in both men and women.

The most common depressive disorders as listed in the fourth edition of the American Psychiatric Association’s Diagnostic and Statistical Manual of Mental Disorders are: (1) Major depression; (2) Dysthymia; (3) Manic-Depression; (4) Cyclothymia; (5) post-partum depression; (6) seasonal affective disorder (SAD); (7) existential depression; (8) mood disorders due to a medical condition; (9) medication-
induced depression; and (10) substance-induced mood disorder. Symptoms of Major Depression include (1) chronically sad or empty mood; (2) loss of interest or pleasure in ordinary pleasurable activities, including sex; (3) decreased energy, fatigue, feeling slowed down, slowed movement; (4) sleep disturbances (insomnia, early morning waking, or oversleeping); (5) eating disturbances (loss of appetite, significant weight loss or weight gains); (6) difficulties concentrating impaired memory, difficulty in making decisions; (7) agitated actions (pacing, hand-wringing, etc.); (8) feelings of guilt, worthlessness or helplessness; (9) feelings of hopelessness and despair; (10) thoughts and/or talk of death and suicide; (11) irritability or excessive crying; (12) social withdrawal or isolation; (13) chronic aches and pains that don't respond to treatment; (14) suicide attempts; and (15) increase in addictive behavior.

According to the *DSM-IV*, five or more of these symptoms should be present for at least two weeks in order for a person to be considered "clinically depressed”. The more symptoms, the more depressed the individual is. And the longer one has experiences these symptoms, the more likely that she is clinically depressed.

In addition to major depression, other depressive illnesses are less severe, for example dysthymia. Some of the most prominent symptoms of dysthymia are: (1) depressed mood for most of the day, for at least two years; (2) difficulties in sleeping; (3) difficulty in experiencing pleasure; (4) a hopeless or pessimistic outlook; (5) low energy or fatigue; (6) low self-esteem; (7) difficulty in concentrating or making decisions; and
(8) persistent physical symptoms that do not respond to treatment (*DSM-IV*). Because dysthymia is not as severe as major depression, dysthymic people do well in psychotherapy and other forms of treatment. It is important not to belittle dysthymia but to treat it vigorously, as it might easily turn into major depressive episodes. Also, because dysthymia is not as severe as clinical depression, the condition is often undiagnosed and/or untreated.

**EXERCISE AND MENTAL HEALTH**

There is some evidence that even in ancient times people knew that exercise is beneficial to health (Green, 1951). The history of exercise and mental health goes as far back as Hippocrates, the father of medicine, who prescribed exercise for individuals suffering from mental illness. In 1899, the Harvard psychologist William James stated that “it is pretty well understood by now that the result of physical training is to train the nervous centers more than the muscles”. The effects of exercise on depression were first reported in 1905 (Frantz & Hamilton, 1905). Vaux (1926) was the first to propose the use of exercise to reduce symptoms of depression. But it was not until the late 1960s and the early 1970s that research on exercise and mental health began to accumulate.

Research on the effects of exercise on mental health is usually approached in two ways: (1) studying how a single exercise session affects psychological states, and (2)
determining the effects of long term participation in exercise on psychological traits. One of the most consistent findings in exercise and mental health research is that a single session of aerobic exercise reduces state anxiety and elevates positive mood factors (Raglin, 1995).

According to Morgan & O’Connor (1988), experts appointed by the US National Institute Mental Health (NIMH) produced a consensus statement on the mental health effects of exercise that concluded that exercise is: (a) Positively linked with mental health and well-being; (b) Reduces stress and state anxiety, and (c) Has emotional benefits for all ages and in both genders.

The psychological benefits of exercise training can be substantial. Some studies have shown that the benefits of a regular exercise program are equal or even better than standard forms of psychological counseling for patients with moderate depression (Greist, 1987; Martinsen 1994).

Research studies have also indicated that brain wave patterns related to positive emotions occur after exercise (Petruzzello & Landers, 1994). These findings constitute a positive test of the mind-body connection. The way we feel after exercising is related to changes in our body that reflect alleviation of stress symptoms (Raglin, 1995). Although these changes are reversed over several hours after exercise, there is evidence that exercise has a longer relaxation effect than an equal-length period of rest or relaxation only (Raglin & Morgan, 1987).
Anxiety and depression share common symptoms (e.g., negative emotions) and may be considered part of the same clinical continuum (Buckworth & Dishman, 2002). In the United States, approximately 40 million adults age 18 years and older (about 18%) have an anxiety disorder that necessitates some form of treatment (Kessler, Chiu, Demler & Walters, 2005). In addition, stress-related emotions, such as anxiety, are common among healthy individuals (Cohen, Tyrell, & Smith, 1991). There have been six meta-analyses examining the relationship between exercise and anxiety reduction (Calfas & Taylor, 1994; Kugler, Seelback, & Krüskemper, 1994; Landers & Petruzzello, 1994; Long & van Stavel, 1995; McDonald & Hodgdon, 1991; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991). These meta-analyses ranged from 159 studies (Landers & Petruzzello, 1994; Petruzzello et al., 1991) to five studies (Calfas & Taylor, 1994) reviewed. All of them found that exercise significantly reduced anxiety symptoms.

The vast majority of the reviews support the conclusion that across studies published between 1960 and 1995 there is a small to moderate effect for reductions in anxiety from both acute and chronic exercise. It is also important to note that the reduction in anxiety occurs for all types of subjects across a variety of conductions using different the measures of anxiety, and regardless of the intensity or the duration of the exercise, the type of exercise (i.e., acute or chronic), or the scientific quality of the studies (Landers, 1998).
During the 1990s there were at least five meta-analytic reviews on depression (Craft, 1997; Calfas & Taylor, 1994; Kugler et al., 1994; McDonald & Hodgdon, 1991; North, McCullagh, & Tran, 1990) that examined studies ranging from as few as nine (Calfas & Taylor, 1994) to as many as 80 (North et al., 1990). In these reviews, the results consistently showed that both acute and chronic exercise are related to a significant reduction in depression.

The vast majority of the exercise studies that looked at the subjective affective states focused more on the chronic implications of exercise (Treasure & Newberry, 1998). Recently, more attention has been given to responses to acute bouts of exercise. Gauvin and Rejeski (1993) even declared that “changes experienced during repeated exposure to activity, as opposed to long term training adaptations, are responsible for certain improvements in mental health” (p. 403). Looking at the effects of an acute bout of exercise on affective response could also explain a potential mechanism for effects of exercise on psychological well-being.

The beneficial effects of exercise are well documented for mild to moderate forms of depression and this provides support for the use of exercise is as adjunct treatment to complement or replace traditional forms of treatment. A therapeutic effect may also be achieved in many other mental health disorders, such as generalized anxiety disorder (Morgan, 1996).
Physical activity may play an important role in the management of mild-to-moderate mental health disorders, especially depression and anxiety. Although people with depression tend to be less physically active than non-depressed individuals, both aerobic and anaerobic exercise have been shown to significantly reduce depressive symptoms (Paluska & Schwenk, 2000). Aerobic exercise is more effective than no treatment regardless of improvements in fitness, and it does not significantly differ from other forms of treatment, including various forms of psychotherapy (Morgan, 1996). Studies have shown that exercise programs provide a substantial psychological benefit, regardless of the type of exercise someone is practicing (strength, flexibility, aerobic): all are proven to be effective and beneficial (Dunn & Dishman, 1991).

Several studies conducted over the past 20 years have supported the mental health benefits of exercise. In 1984, McCann and Holmes randomly assigned 41 women with depression measured by the Beck Depression Inventory (BDI) to three different conditions: relaxation training, aerobic exercise, or waiting list control group. After a 10 week period there were significant reductions in BDI scores in both treatment groups, but the reduction in the aerobic group was significantly greater than that observed in the other two conditions.
A study done by Egil Martinsen (1989) found that exercise programs of either walking/jogging or stretching significantly reduced patients’ anxiety levels. The study was conducted with 99 individuals hospitalized with major depression (DSM-III-R), dysthymic disorder or other depressive disorders. Both exercise programs were equally effective, and the amount of psychological improvement was not related to fitness gain. This is a very important finding because it had been suggested that exercise programs must increase cardiovascular capacity for psychological benefits to take place. In an earlier study, Martinsen (1985) had indicated that the decrease in depression was significantly correlated with the increase in cardio-respiratory fitness. The controversy is still alive, as the latest review on this topic by Dunn, Trivedi, and O’Neal in 2001 concluded that it is not clear whether or not increases in cardiorespiratory fitness are necessary to reduce symptoms of depression. It should be noted that most studies have shown that fitness improvements are not needed to improve mental health. Also, beside exercise, habitual physical activity has been associated with increased physical, psychological and mental health (Anthony, 1991).

Some of these findings are consistent with theories (e.g., Sonstroem & Morgan, 1989) that suggest that changes in self-perception of fitness, rather than actual fitness improvements are enough to enhance self-esteem, which is a hypothesized psychosocial mechanism for exercise induced reductions in depression and anxiety. However, it is
possible that the subtle changes in physical capacity produce psychological benefits (Raglin, 1995).

The effect of exercise on mood is well documented, and bouts of exercise have been associated with improved mood. It is interesting to notice that improvement in mood measured by the Profile of Mood States (POMS) is dependent on the pre-exercise mood parameters and the improvement is significantly greater among individuals that report symptoms of depressed mood before exercise (Lane & Lovejoy, 2001). According to the Law of Initial Values (LIV), the magnitude of a response is dependent on the initial baseline. Applied to effects of exercise on mood, if you are very depressed, there is a better chance that you can improve your mood than if you feel good to begin with.

Exercise history of the participants may play a role in this relationship. In the study by Lane and Lovejoy (2001), the participants were 80 people who had attended an exercise class on a regular basis for the previous three months. The participants completed the Profile of Mood Change (POMS) with 15 minutes prior to the exercise session. Participants were then grouped either a no-depression group, or a depressed mood group using pre-exercise depression scores from POMS. The results showed an improved mood for both groups but this effect was significantly higher for the depressed mood group. As exercise history of individuals’ changes, these results could change also and it is difficult to isolate the result of the bouts of exercise by themselves as many confounding factors are changing the dynamic of the mood improvements.
Unlike most of the older studies that looked at the effects of acute or chronic exercise on the mood of participants, Berlin, Kop and Deuster (2006) examined the effects of limiting or stopping the exposure to exercise on mood. They took 40 participants who exercised regularly according to the ACSM recommendations and divided them into two equal groups: one was allowed to continue to exercise and the second one was forced to stop exercising (withdrawal of exercise). After a week, the group that was randomized to exercise withdrawal showed significant (p=0.05) deterioration of mood affect as measured by the POMS, depressive symptoms measured by BDI-II, and fatigue (Multidimensional Fatigue Inventory). Although this study is important because it shows negative effects on mood from withdrawal of exercise, there has not been decisive evidence that exercise, in any format (acute or chronic) can prevent depression. However, even if exercise cannot prevent depression, it can help alleviate its symptoms, as highly active individuals are less likely to become severely depressed when they are mildly depressed (Raglin, 1990). In these lines, a longitudinal study examined the dose-response relationship between depression and self-reported physical activity using cross-sectional and prospective data between from middle-aged women between 1996 and 2001 (Brown, Ford, Burton, Marshall & Dobson, 2005). Participants completed surveys that included questions about the amount of time spent in different types of PA. A clear dose–response relationship was found between increasing physical activity and decreasing depressive symptoms.
Another study examined the effects of a bout of exercise on psychological variables for a group of 40 participants who were receiving treatment for major depressive disorder (Bartholomew, Morrison & Ciccolo, 2005). The authors divided the sample into two groups, one required to complete a 30 minute bout of exercise at 60-78% of max heart rate and the other rested quietly for 30-min. The psychological variables were assessed using the Profile of Mood States (POMS) and Subjective Exercise Experiences Scale (SEES) at various points in time: 5 min before, and 5, 30, and 60 min post-test. Both groups reported similar reductions in measures of psychological distress, depression, confusion, fatigue, tension, and anger but only the exercise group was associated with a significant increase in positive well-being and vigor scores.

As mentioned above, regardless of intensity and type, exercise has been associated with positive changes in depression and anxiety. Researchers have studied and quantified the benefits of various forms of exercise (e.g., aerobic vs. anaerobic, preferred vs. prescribed, low vs. moderate vs. high). Unfortunately, there is still debate about the exact magnitude of the benefits or the effects of exercise on mental health, especially with respect to the intensity of the exercise.

A study showed that lighter forms of exercise (40% of VO$_{2\text{max}}$) are as beneficial as vigorous activity (Raglin, Wilson & Morris, 1993), suggesting that you do not have to exercise at a very high intensity to gain the benefits and stress relief through exercise. In the same context, another study (Moses, Steptoe, Mathews & Edwards, 1989) reported
the effect of training at a high intensity or moderate intensity compared to placebo and waiting list control conditions over a 10-week period in 109 initially sedentary adults. The authors found significant affect changes only for the moderate intensity group and hypothesized that this is due to the fact that high intensity exercise training is too challenging, while the moderate intensity was associated with better satisfaction and adherence.

Based on their review of exercise studies using POMS, Berger and Motl (2000) recommended exercise for at least 20-30 min at moderate intensity to be the adequate dose to get the psychological benefits. Moderate intensity might not be the best choice when looking for fitness benefits, but it showed a consistent pattern for mood changes (Motl, Berger & Wilson, 1996). High intensity exercise on the other hand has been linked with either no mood changes or even negative mood changes (Motl et al., 1996; Steptoe & Cox, 1988).

Although more recent reviews have supported moderate over higher intensity exercise for mood benefits, not too long time ago, well-being was associated with vigorous exercise (Morgan, 1985) and exercise prescriptions were designed accordingly. But vigorous exercise is associated with lower adherence (Lee et al., 1996) and the fact that over time researchers have not observed an increase in adherence has been linked to the intensity of the original recommendations. More recent recommendations have therefore been relaxed, as researchers have gone away from the vigorous exercise
prescriptions. This has given birth to an interesting paradox, as on one hand we know that vigorous activity is beneficial for the health but it is also associated with higher drop-out rates than moderate activity. So, would lowering the intensity help? It might be associated with a higher adherence, but is this adherence complemented by meaningful mental health benefits? If the benefits are triggered by some mechanisms (e.g., self-efficacy improvements, countering learned helplessness, post exercise effects proposed by the opponent process theory), does exercise have to be at an intensity above a certain threshold in order for the mechanisms to function and consequently result in the psychological benefits?

A study conducted by Treasure and Newberry (1998) agreed with others (Gauvin & Rejeski, 1993) in terms of the benefits of studying the impact that an acute bout of exercise had on psychological benefits. Their study also supported Bandura’s theory that the more the challenging the task the greater the potential for increasing efficacy perceptions (Bandura, 1997). Treasure and Newberry (1998) examined the relationship between self-efficacy, feeling states and different levels of exercise intensity during and after an acute bout of exercise. Sixty undergraduate students were randomly assigned to a moderate intensity, high intensity or a control group. The study found that in-task physical exhaustion in the high intensity session predicted post-exercise self-efficacy. In other words, the results might suggest that the high intensity exercise is better, because it would increase post exercise self-efficacy (even though the individuals reported
discomfort during the exercise session). The authors disagreed with this possible
interpretation of their results, claiming that the discomfort during exercise does not pay
off, as most people would suffer during the high intensity exercise (figuratively and
literally).

One study showed that actually these psychological benefits occur only in fit or
experienced exercisers (Dishman, Farquhar & Cureton, 1994). The participants were 23
male students divided into two groups, with 11 classified as high-active and 12 classified
as low active. They were asked to self-select the power output for a 20 min cycling
session. During the first 5-10 min of cycling, the high-active group selected higher power
outputs than did the low-active group. The exertion was the same, but only the high-
active participants reported a significant reduction in state anxiety immediately after
cycling, although this was confounded by self-selection of intensity.

Some studies show that high-intensity exercise should be avoided because it will
actually raise anxiety, others indicate otherwise, as several studies have shown that very
intense (80% of VO$_{2\text{max}}$) or even maximal exercise improves state anxiety and mood
(Pronk, Crouse, & Rohack, 1995). The reduction in anxiety may be delayed for a few
minutes following intense exercise, but the amount of improvement is similar to that
found after moderate activity.

Although the potential benefits of exercise for alleviating the symptoms of
depression have been generally accepted for centuries (Buckworth & Dishman, 2002),
the usefulness of exercise for modifying anxiety has not always been accepted. Forty years ago a study found that anxiety neurotics had panic attacks when given intravenous doses of lactate (Pitts & McClure, 1967). A link made by researchers based on the fact that lactate levels increase with the exercise intensity implied that exercise was also likely to cause panic attacks. More recent findings dispute this view and show that people with anxiety disorders can safely engage in vigorous exercise (Martinsen, Raglin, Hoffart & Friis, 1998).

A study by Steptoe and Cox (1988) supported the historical association between high intensity exercise and increased level of anxiety. However, in their study the exercise intensity was manipulated in terms of absolute as oppose to relative workloads. Cox and his colleagues (Cox, Thomas, Hinton, & Donahue, 2004) used relative intensities in their study on the effects of acute bouts of aerobic exercise on state anxiety in women. Twenty-four active women, ages 18-20 years (n = 12) and 35-45 years (n = 12) exercised at 60% VO_{2max} and at 80% VO_{2max}. Each exercise session consisted of a 33-min bout. Participants were given the Spielberger State Anxiety Inventory (SAI) before the exercise session, after the exercise session and at 30, 60, and 90 min post exercise. All three exercise conditions (including control) showed a decrease in state anxiety across time, but the 80% VO_{2max} condition showed a sharper decline. In conclusion, after using relative workloads to manipulate exercise, the high intensity was
more effective than moderate intensity in reducing state anxiety (e.g. lower SAI scores) in women.

Another study that questioned the moderate intensity as being superior to the high intensity in terms of mood improvement equated the total volume of work between exercise conditions (Blanchard, Rodgers, Wilson & Bell, 2004). The study looked at a community sample of exercisers during a 12-week exercise program and compared feeling state changes of those who exercised at a higher intensity-shorter duration (HISD) and at a lower intensity-longer duration (LILD). The study showed that regardless of the condition, when equating for total volume of work between the exercise conditions, positive well-being and fatigue significantly increased, whereas psychological distress significantly decreased from pre to post exercise.

When looking at changes in feeling states, previous research compared low versus high intensity while holding duration constant (Blanchard et al., 2001, 2002; Bulbulian & Darabos, 1986; Farrell, Gustafson, Morgan, & Pert, 1987; Gauvin, Rejeski, Norris, & Lutes, 1997; Treasure & Newberry, 1998). Blanchard and his colleagues used an alternative method by “trading intensity for duration” (see Hardman, 2001). Thirty-five women and nine men were randomly assigned to a higher intensity-shorter duration (HISD) or a lower intensity – longer duration (LILD) 12 week exercise program. As a method of measurement, they used the Subjective Exercise Experiences Scale (SEES). The SEES consists of three distinct factors, two of these factors correspond to the
positive and negative poles associated with psychological health, Positive Well Being (e.g., positive, terrific; PWB) and Psychological Distress (e.g., miserable, discouraged; PD), while the third factor gives subjective indicants of Fatigue (e.g., exhausted, tired). The results of the study showed that regardless of the exercise intensity, PWB and fatigue increased significantly, whereas PD significantly decreased from pre to post regardless of the exercise session when the total volume of work was equated. A very interesting result of this study showed that the fit individuals respond to acute exercise bouts with higher levels of PWB and lower levels of PD and fatigue. Although not mentioned by the authors, this result is in accordance with the Opponent Process Theory that predicts a higher magnitude of the b-process when the individuals have a history of exposure to the stimulus. A detailed discussion of the parameters and assumptions of the Opponent Process Theory can be found on pages 41 – 45.

Some research has been conducted to examine the relationship between exercise intensity and depression. Lampinen, Heikkinen and Ruoppila (2000) looked at exercise intensity as a predictor of depressive symptoms among adults age 65 or older during an 8 year period. Approximately 90% (N=663) participants participated in baseline (1988) and follow-up (1996) assessments. The results showed that those who reduced their exercise intensity reported more depressive symptoms than those who stayed active or increased their level of physical activity. This study also supports the fact that low levels of physical activity level predict depressive symptoms.
A randomized controlled study tried to demonstrate the efficacy and dose-response characteristics of weigh lifting exercise for depression (Singh, et al., 2005). Sixty clinically depressed elderly participants were randomized to a high intensity progressive resistance training (PRT) or low intensity PRT. The study found that the high intensity resistance training was a more effective treatment than the low intensity in reducing depressive symptoms so it appears that in order to get a significant depression reduction a high intensity might be required.

It is interesting to notice that these studies are trying to challenge the current state of thought regarding the optimal intensity of exercise. Not unrelated to the ACSM recommendations, the quasi-consensus is that moderate intensity suffices for experiencing health benefits and it is the optimal level of exercise intensity prescription. Credit should be given to the researchers that go outside the box, try to deploy more powerful statistical models, and better designed studies in order to determine the right balance between intensity and benefits. In addition, it is worth mentioning that one of the pioneers of the exercise psychology has recommended vigorous intensity as the one that is associated with better health and improved mood affects (Morgan, 1985).

The studies we reviewed above show that the debate regarding the optimal intensity of exercise is still on going. Researchers are going back and forth between the benefits of a certain intensity over another and we still do not have a consensus as to which intensity provides the best psychological benefits.
An important variable that needs to be part of all studies when looking at the effects of an acute bout of exercise is the time needed for the exercise effects to be experienced after an acute bout of exercise; when looking at the b-process from Opponent Process Theory, how much time (delay onset) is needed for the b process to appear. Reductions in state anxiety and improvements in psychological well-being are not always observed immediately following exercise. Studies have shown that there might be delays of even 30 min until one can notice a decrease in state anxiety (O’Connor, Bryant, Veltri & Gebhardt, 1993).

Raglin and Wilson (1996) looked at the differences in responses in state anxiety (SA) following four different types of intensity. Five women and 10 men exercised for 20 min on a bicycle ergometer at 40, 60, or 70% \( \text{VO}_{2\text{peak}} \). State anxiety was measured following each exercise session, and 5, 60 and 120 min post-exercise. The study revealed a decrease in SA after each exercise condition. State anxiety was significantly reduced at all post-exercise assessments in the 40 and 60% \( \text{VO}_{2\text{peak}} \) conditions. Interestingly, it was elevated at 5 min following exercise at the highest intensity and below baseline at 60 and 120 min post-exercise. The increase in state anxiety was only seen in participants with low baseline state anxiety levels. The study showed that for young healthy individuals, a 20-minute acute bout of exercise at 40, 60, or 70% \( \text{VO}_{2\text{peak}} \) is effective in reducing SA, but in the case of the high intensity, the benefits are not seen immediately. Although not mentioned by the authors, this result is consistent with the OPT, as a higher intensity of
the stimulus (exercise) implies higher magnitude for both a- and b-processes, and the higher magnitude of the a-process delays the relative positive effect associated with the b-process (as compared with the baseline value).

Along the same lines, Cox, Thomas and Davis (2000) found similar results for the effect of high intensity on SA, but unlike the previous study, the effect of the moderate intensity on SA was also delayed. Twenty-four participants completed 30 min of exercise on their assigned apparatus (either a treadmill or a stepper) at an intensity of either 50% or 75% VO$_2$max. Measurements of SA at 5, 30, and 60 min after exercise demonstrate a delayed anxiolytic effect independent of exercise mode. The results showed that exercising at 50% or 75% VO$_2$max does not immediately (not before 5 min) result in a reduction in SA but a decrease in SA was observed at 30 and 60 min following the exercise session.

The delayed effect of exercise on affect after an acute bout of exercise is discussed in many studies, and is likely a function of many factors, such as intensity, age, exercise history, and health status. In a somewhat comprehensive study on the effect of exercise on depression, Cox, Thomas, Hinton and Donahue (2006) grouped 24 active Caucasian females into two age groups: 18-20 year (n=12) or 35-45 year (n=12). “Active” was defined as participating in cardiovascular exercise at least three times a week for 20-min or more each time and in good physical health. The methodology of the study was rather complex, as the authors measured both psychological and physiological
variables. Psychological affect was assessed using the Subjective Exercise Experiences Scale (SEES). Perceived exertion was measured using Borg's Rating of Perceived Exertion (RPE) scale (Borg, 1977). RPE was assessed at the 15, 20, 25, and 30-min points of a 33-min bout of acute exercise. Blood was collected from a butterfly needle inserted into an antecubital vein in order to get serum ferritin (sFer) measurements (which were studied as covariates). Participants completed three sessions: control (sitting on a chair placed on a treadmill) or running on a treadmill at two intensities: 60% or 80% for 33-min. Participants completed the SEES before each session and following each of the three sessions, at 5, 30, 60 and 90-min post-exercise. The authors found that the covariates had minimal effect on the dependent variables. Both moderate and high intensity sessions increased psychological well-being. No significant differences were noticed between moderate and high intensity for fatigue and psychological distress, but the high intensity was associated with higher positive affect. Psychological distress decreased regardless of exercise intensity condition but the reduction was not significantly different from the one experienced by the control group. The two exercise intensity conditions showed better results than the control condition for positive well-being, for both the younger and older women. Moreover, the higher intensity was associated with more elevated positive affect than the moderate intensity. Cox et al. (2006) did not find a delay in the psychological effect after exercise. They concluded that this was because of the scale they used, as other studies have noticed this delayed
response using other scales. The authors were also interested in the interaction involving age and the other relevant variables. After controlling for iron status, they found only two age-related interactions: the 2-way age by intensity interaction for psychological distress and the three-way age by intensity by time interaction for positive well-being. Hence, the age of female participant may be an important moderator, which could alter the relationship between positive and negative mood at different levels of exercise intensity and across time. The fact that this interaction is significant is very important because it raises questions about other moderators of the effect of exercise, and the list of potential suspects can be very long, from the mode of exercise to any demographic variable.

Daley and Welch (2004) studied the effect of two bouts of exercise of 15 min and 30 min on affective responses. The participants were 23 physically active adults and the mode of exercise was cycle ergometer. They completed the SEES scale before, during and 5-min, 30-min, 1-hr and 2-hr post exercise. The authors found no significant differences between the two sessions (15 min or 30 min), with a significant increase in positive well-being and significant reduction in psychological distress and fatigue post exercise regardless of the duration of exercise. Moreover, these effects lasted at least 2 hr, regardless of the duration of the exercise session.

An important aspect of the effect of exercise is the relationship between exercise and other traditional treatments for depression, including the possible interaction between
multiple treatments. Is the effect of various treatments additive (i.e. are the positive effects of one treatment being added to the positive effects of another?).

In a study done by Freemont & Craighead (1987), 49 participants with elevated depression scores (measured also by the BDI) were randomly assigned to cognitive therapy, aerobic exercise, or a combination of the two. Significant reductions in depression scores were obtained in all groups after 10 weeks but there were no significant differences between the groups.

One of the most recent studies (Knubben et al., 2007) looked at the effects of a short-term (10-day) endurance training program in patients with major depression. The participants were randomly assigned to an exercise (walking, n = 20) or placebo (low-intensity stretching and relaxation exercises (n = 18) group and they also continued standard clinical antidepressant drug treatment. Participants had experienced depressive episodes with a score of > 12 on the Bech-Rafaelsen Melancholy Scale (BRMS) – corresponding to moderate to severe depression. The subjective mood changes were assessed before and at the end of the study using the Center for Epidemiologic Studies Depression scale (CES-D). At the end of the study, the exercise group had a substantially greater reduction in depression scores (36%) than the control group (18%; p=0.01) but the interaction with medication was not significant (F=2.24, p=0.09) showing that each intervention (medication or exercise) does not facilitate a better response for the other than the intervention by itself. In other words, according to this study, the effects of the
two treatments are not additive. In addition, the reduction in the CES-D scores was substantially greater in the endurance training group (41%) than in the control group (21%, p=0.01).

A randomized controlled trial (Blumenthal et. al., 1999) compared an aerobic exercise program, antidepressants medication and a combination of both for treatment in older adults between 50-77 years of age with major depressive disorder (MDD). All participants (N=156) were diagnosed before and after treatment using DSM-IV criteria and Hamilton Rating Scale for Depression (HAM-D) and Beck Depression Inventory (BDI) scores. Other measurements included aerobic capacity, life satisfaction, self-esteem, anxiety, and dysfunctional cognitions. After 16 weeks of treatment, all three groups exhibited a significant decline in depressive symptoms on HAM-D and BDI scores. The results showed that the group that was on medication alone had the fastest response to treatment but after the 16 weeks of treatment, exercise was equally effective in reducing depression symptoms. As part of the same study, but published in a different paper (Babyak et al. 2000), the authors looked at the dropout rates 6 months after the treatment (i.e., after 10 months). The participants in the exercise group had significantly lower relapse rates than participants in the medication group. The exercise sessions were conducted in a group setting, so a limitation of the study was the social interaction that could confound the effects of exercise, although better adherence at follow-up after the intervention countered this. However, social support may have influenced the impact of
the exercise during the intervention, and depressed individuals may need a structured and supervised setting to sustain benefits of exercise.

In a recent study (Dunn, Trivedi, Kampert, Clark & Chambliss, 2005) social support was controlled during a 12-week exercise intervention by asking the participants to exercise individually in rooms by themselves but were monitored by laboratory staff. Eighty adults aged 20-45 with mild to moderate major depressive disorders were randomized to one of four different exercise treatment groups that varied total energy expenditure (7.0 kcal/kg/week or 17.5 kcal/kg/week) and frequency (3 days/week or 5 days/week) or an exercise placebo control (3 days/week flexibility exercise). The 17.5-kcal/kg/week dose met public health recommendations for physical activity. The results showed that Hamilton depression scores were reduced by 47% in the public health dose group compared with 30% for the low dose and 29% for the control group. There was no difference if the exercises were done 3 or 5 days a week, suggesting that the determinant factor for reducing depressive symptoms is total energy expenditure.

An important factor in the exercise-depression equation is the perception of the patients with respect to the value of the exercise as a treatment for depression. Do they value exercise just as much as they value medication or counseling? Can researchers or practitioners do something different to improve this perception if it is below the actual value of exercise treatment? In general, participants in exercise programs have positive views about exercise. A study that evaluated the perception of exercise value for
psychiatric outpatients (Pelham & Campagna, 1991), reported that following a 12-week exercise program, the perception was positive and people valued exercise as a treatment for their problems. More research is needed in order to get a comprehensive view of the perception of exercise, both as bouts or as programs, both as a primary or adjunct treatment for depression.

In spite of all the research demonstrating the relationship between exercise and mental health, professionals have been reluctant to endorse the use of exercise in treating mental illness, as 90% of psychotherapists do not recommend it at all (McEntee & Halgin, 1996). Moreover, exercise has not been widely adopted by clinical psychologists as a viable adjunctive intervention strategy for improving the mental health of patients (Daley, 2002). Still, this point of view can be understood in light of the limitations of the literature on this subject. For example, it has been emphasized in earlier reviews (Morgan, 1997) that research in this area has been characterized by a number of methodological problems. Hughes in 1984 concluded that only 12 of 1,100 published articles involving the influence of exercise on mental health were acceptable from a methodological point of view. An update (Dunn Trivedi, & O'Neal, 2001) found only 37 studies that were focusing on exercise and anxiety and depression qualified for the review on the basis of satisfactory methodology. An interesting parallel between the state of psychotherapy in the early 1950s and current state of exercise and mental health is made by Morgan (1997). The efficacy of both psychoanalysis and psychotherapy were
questioned when Eysenck (1992) published a paper showing that 44% of patients improved with psychoanalysis, 64% improved after psychotherapy, but 72% of patients in control groups improved. The author also states the need for better research in the area beyond simplistic arguments and speculations. These ideas, combined with the fact that there is no clear mechanism for the benefits of exercise on mental health may contribute to reluctance in psychologists and organizations for recommending exercise as treatment for mental health problems.

PRESCRIBED VERSUS PREFERRED INTENSITY

As mentioned above, many studies have shown that the beneficial effect of exercise for depressed patients is generally independent of the exercise type. Also, studies have shown that physical activity has benefits at various intensities, but the results are inconsistent. This allows us to ask the following question: which intensity (if any) brings the most psychological benefits? Having this question in mind, a few recent studies have looked at the effects of exercising at a prescribed intensity versus the effects of exercising at a preferred intensity.

In our study, participants are exercising at moderate and high intensity and in the end, they are asked to self-select one of the two sessions. Although this would be their choice, it is not quite their absolute preferred intensity, as it is their choice only relative to two prescribed intensities. It is still important to review the literature surrounding
preferred and self-selected intensities and to analyze the extra benefits (if any) given by the differences in affect experienced by participants at the same intensity but as a function of choice vs. prescription.

Another important issue in prescribing exercise for mental and physical health benefits is the establishment of the intensity limits within which one should exercise in order to receive at least some of the expected health benefits. If people do not self-select intensities that are associated with health benefits, then it would not make sense to leave this choice in their hands. On the other hand, if they do select intensities associated with health benefits, are there psychological benefits related to the fact that the intensity is their choice?

Spelman in 1993 looked at the self-selected exercise intensity of habitual walkers. Twenty-nine healthy adults performed a typical exercise walk on a treadmill while walking speed was measured by an unseen observer. The mean self-selected walking pace was 1.78 ± 0.19 m/second (3.96 ± .33 miles/hour). Mean percents of VO$_{2\text{max}}$ and HR$_{\text{max}}$ elicited by the treadmill exercise were 52% (SD=11) and 70% (SD=9), respectively. The study suggests that the self-selected intensity meets the American College Sports Medicine’s recommendation for improvement of cardiorespiratory fitness (40-85% VO$_{2\text{max}}$ and 55-90% of HR max). We also found that sedentary depressed women, when selecting a preferred intensity, chose to exercise on a cycle ergometer at intensities within the ACSM recommendations (Rozorea, Buckworth, Granello, Mattern,
Dishman et al (1994) showed that both high and low-fit individuals select work rates on a cycle ergometer that are around 60% VO$_{2\text{max}}$ after 20 min of exercise. Finally, a study by Glass and Chvala (2001) showed that participants allowed to self-select exercise intensity chose work rates that are within the ACSM’s guidelines of 40-85% of VO$_{2\text{max}}$. So, when given the choice of intensity, participants tend to choose an intensity that provides health benefits.

Ekkekakis and Petruzzello (1999) only found two published articles about self-selected exercise intensities and both of them studied non-depressed participants. In the first study by Farrell et al. (1982), six well-trained athletes ran on a treadmill for 30 min at a self-selected intensity either at 60% of VO$_{2\text{max}}$ or 80% of VO$_{2\text{max}}$. The study reported results that referred only to the Total Mood Disturbance (TMD) score of Profile of Mood States, which were not statistically different after the three exercise conditions. In the second study, Zervas et al. (1993) examined the mood states in female participants after 30 min of aerobics performed at a self-select intensity and at 40%, 60%, and 80% of maximal heart rate (MHR). Vigor and exhilaration increased after the 60% and 80% MHR as well as after self-selected intensity. However, enjoyment was higher on those who self-selected their intensities.

Another study (Parfitt et al., 2000) measured psychological affect and exercise enjoyment in aerobically fit individuals. The study compared the effects of 20 min of treadmill exercise at a prescribed intensity exercise (65% VO$_{2\text{max}}$) and a preferred
intensity exercise on the above mentioned variables. Results indicated that there was no
difference in psychological affect or enjoyment between the two exercise sessions,
although work rate was higher in the preferred condition.

It is important to mention that some studies were done on self-selected intensities
and others on preferred intensities. The difference between those two is that the preferred
intensity is usually established through an exercise protocol, and in the same time
enjoyment seems to be a more critical variable in this condition than it is in the self-
selected condition. The issues around selection of exercise intensity are important
because the use of preferred intensities has been seen as a way to increase adherence to
exercise programs (Dishman, 1994).

We talked about the notion of preference and self-selection with respect to the
intensity of the exercise. A similar discussion could be started for other parameters of an
exercise session. One of the most important is related to the mode of exercise. Are there
differences in affective effects of exercising at various modes? What modes are the most
beneficial for mood improvements?

It is interesting to notice that in most studies that have considered the exercise and
affect relationship, researchers have tended to prescribe cycle ergometry. Daley and
Maynard (2003) conducted a study in this direction that indicates that practitioners should
consider exercise preference more closely when promoting the psychological benefits of
exercise. Twenty-six physically active adult participants engaged in three
counterbalanced conditions for 30 min: (1) cycle ergometry, (2) choice of exercise mode and, (3) television control condition. The Positive and Negative Affect Scale (Watson, Clark & Tellegen, 1988) was administered to participants pre-, mid- and post-condition. During and after exercise, significantly higher Negative Affect scores were reported for the no-choice cycle ergometry condition compared to the exercise choice and control conditions. A group main effect was recorded for Positive Affect with the control group reporting significantly higher scores compared to the cycle ergometry condition. Hence, the group with the most freedom (those who could watch television) recorded the best positive affect. This shows that when trying to improve psychological affect, not only the intensity is important but also the exercise mode. It should be noted that it is possible to have different preferred intensities for different exercise modes and this interaction is extremely important when trying to optimize the benefits of exercise on mental health.
THEORY AND HYPOTHESIZED MECHANISMS

The positive effect of exercise on depression is well documented but the mechanism through which it works is not well known. Recent research has focused on determining theories and mechanisms that can explain this positive effect.

OPPONENT PROCESS THEORY

Opponent process theory (OPT) mirrors a well-known principle from classical mechanics, “action and reaction”. But unlike Newton’s third law of motion, which states that to every action there is an equal and opposite reaction, the two OPT forces are lagged (the second one starts when the first one ends) and they are not necessarily equal (their intensity is a function of the stimulus). In short, OPT asserts that the emotion experienced while being stimulated is followed by an opposite emotion once the stimulus ends, and that the shift happens as soon as the stimulus ends. The magnitude of the first emotion is compared to the magnitude of the second, opposite emotion, different stimuli being associated with different magnitude of responses for the two processes. As an example, in this theory, the nervous system tends to counteract any deviation from the pre-stimuli initial point on the pain-pleasure or fear-relief continuums. The two internal processes that produce this pattern are called the a-process, which is responsible for the initial
emotional reaction and the b-process, which is responsible for the after-reaction (Solomon, 1980). Just like the high tides are followed by low tides, the first process response is followed by the second, opposite process. And just like physics or oceanography, the underlying force that governs these processes is the fact that everything in the world has a tendency to seek equilibrium.

The Opponent Process Theory can be studied in the context of different types of stimuli, from the reaction to electric shocks to the emotions of skydivers jumping from planes, which was the subject of the original study upon which the theory was developed. For us, the stimulus is an exercise session. In this case, the theory would suggest that while exercising, people are in general affected by negative emotions associated with the effort or even pain. Immediately after the exercise session ends, the negative affects are reversed and are replaced by positive emotions like pleasure, satisfaction or sense of accomplishment. The opponent process tends to bring the organism into equilibrium. How long these processes last, the magnitude of the emotions associated with them, and the time it takes the organism to get back to equilibrium (e.g., pre-stimulus state) are important questions for evaluating the benefits of the stimulus.

The opponent process theory enables us to segment the affective effect of exercise into two phases: the first phase, during exercise, is dominated by reduced positive affect (a-process). The second phase, which starts as soon as the exercise session ends is described by a rapid, complete shift towards positive affects (b-process).
The biological foundation of this theory is suggested to be linked to opioids, primarily beta-endorphin (Solomon, 1980). Opioidergic neurons have an inhibitory effect on the sensory cues from joints and muscles originated in stressful stimuli (Yamada & Nabeshima, 1995). While the biology of opioids drives the b-process, metabolic acidosis is the force underlying the a-process. Opioids and metabolic acidosis are opposite processes. It is interesting to notice that the b-process is dependent on an intensity of the a-process above a certain level and this value is the same as the lactate and ventilatory thresholds (Sgherza et al., 2002). This is a scientific reminder of the popular old-saying, “no pain, no gain!” The effort and the pain or discomfort associated with exercising have to be above a certain level in order to gain the post-exercise psychological benefits of positive affect. The study of thresholds for these effects in respect to exercise prescriptions is important, as researchers try to determine the optimal range of exercise intensity in terms of psychological benefits. Maximizing psychological benefits also has implications for adherence to exercise programs and other metrics of the exercise scorecard, like maintenance.

A major limitation in testing the OPT is the difficulty in measuring the affect at various points in time: prior to, during and post exercise. Rather than looking at a static picture of affect, the measurements and analysis need to follow a flow of emotions and hence we are dealing with a dynamic, continual process.
In a recent study, Lochbaum et al. (2004) mention that although several researchers had cited Solomon's work as potential support for their results, they found none that included measurement time points during exercise. Without measurements during exercise, we cannot completely understand the evolving nature of the affect response, and we lack data on the a-process. Anything short of this would only give us a partial answer to the question of the individual response to the stimulus and hence would be a methodological weakness that limits the application of the theory.

The opponent process theory has two dimensions. One talks about the opposite “a” and “b” processes, while the second one, a little more subtle, differentiates the response in terms of the historical exposure to the stimulus (e.g. exercise history). The theory would predict lower negative affect during exercise and higher positive affect after exercise for fit individuals, compared with unfit individuals. This dimension of the theory was refuted in a study by Petruzzello, Jones, and Tate (1997), who found no significant fitness group differences in response to acute exercise with respect to the SAI (State Anxiety Inventory) and SEES (Subjective Exercise Experiences Scale). Based on OPT it was hypothesized that fit individuals (n=18) would have a reduced negative and/or increased positive affect compared to the unfit individuals (n=12). The authors concluded that the results partially support the OPT. They reported a significant Group x Time interaction for affective valence and lack of support for anxiety and fatigue.
A similar more recent study (Blanchard, Rodgers, Spence & Courneya, 2001) supports these results. Twelve highly fit and 12 unfit females were exposed to two acute bouts of exercise at 50% and 80% of age-predicted maximal heart rate reserve. Pre- and post- feeling states were measured using SEES. Well-being and fatigue were not correlated with fitness level. The major limitation of the study is that there were no measurements during exercise. Again, one can test the theory only through complete measurements pre, during and post exercise, because the timing of the assessment allows us to understand the entire nature of the exercise experience and the continual, gradual response to it. Also, segmenting the population into homogeneous classes (based on any factors that might affect the response) is mandatory to avoid the presence of confounding factors.

The most recent study that investigated Solomon’s theory in the context of exercise stimulus (Bixby et al., 2006) used an improved methodology, measuring affect pre, during and for 30 min after exercise, asking the participants to report RPE and having the exercise intensity prescribed based on ventilatory threshold. Fifteen fit and 17 unfit participants completed bouts of exercise at low and high intensity. The authors found that the three-way interaction among participant group (fit and unfit), time (pre, during, post) and exercise intensity (low and high) was not statistically significant. The opponent process theory was again partially supported (they found the pattern of
temporal affect rebounding) but also partially refuted (the affective response during recovery was not statistically different between fit and unfit individuals).

HYPOTHESIZED MECHANISMS

There are many hypothesized mechanisms by which exercise is thought to influence mental health. Although several psychobiological and social-cognitive models and theories have been suggested, it is difficult to undoubtedly accept any single mechanism because research supporting the relationships has been weak, with many studies being poorly designed (Daley, 2002). Still, although evidence supporting psychologically based explanations is not conclusive, these mechanisms are intuitively appealing and more research is needed to determine their reliability and validity.

There are many different reasons that physical activity is an important tool in the fight against depression, such as the low cost and the concomitant benefits for physical health. Although the positive effect of exercising is not in doubt, the mechanisms that trigger the benefits are not known entirely and exhaustively. Two of these potential mechanisms are directly related to our study.
Learned Helplessness

Exercise can affect depression through psychological mechanisms (increased sense of control) and also through physiological mechanism (e.g., serotonin). Sense of control is a component of the Learned Helplessness (LH) model, which describes the maladaptive response of an organism to stimuli. Over a period of time, the organism learns whether the stimuli can be controlled or not. If the organism believes that it cannot control the stimuli, it will ignore it, and it does not even try to respond.

Learned Helplessness refers to the behavioral consequences of exposure to stressful events over which the organism has no control (Seligman & Maier, 1968). Animal studies have shown that sedentary rats exposed to uncontrollable shocks are less likely to learn to escape from escapable stress (Weiss & Glazer, 1975). Also, they exhibit exaggerated fear responding to stimuli (Maier, 1990). The parallel between animal and human behavior is positively tested, as laboratory animals resemble those of human for depression and anxiety (Maier & Watkins, 1998). Some studies have been conducted to test the effects of exercise on depression using an animal model of LH. For example, in a study focusing only on shuttle box escape and excluding nonstressed controls, it was shown that activity-wheel running reduced LH (Dishman et al., 1997).

Endorphin hypothesis

The possible release of endogenous opioids (Steinberg & Sykes, 1985) after acute bouts of exercise is the basis for the endorphin hypothesis, which was developed in the
1980s. In animal studies, increased opioids in the blood of rats that were forced to exercise supported the endorphin hypothesis (Pert & Bowie, 1979; Wardlaw & Frantz, 1980). Positive human experiments (Farell et al., 1987; Raglin & Morgan, 1987) were followed by research that showed no correlation between the positive mood changes after exercise and peripheral β-endorphin levels (Kraemer et al, 1990). Moreover, a strong limitation of the hypothesis is that endorphins that may be produced peripherally in response to exercise do not cross the blood–brain barrier, so these opiates are unlikely to reach the brain and contribute to mood changes (Farrell, 1989). However, limitations on measurement of central opioid response in humans prevent conclusive judgments about the endorphin hypothesis. The original proposal that endorphins are responsible for the b-process may still be plausible for exercise, but this has not been tested as a biological mechanism for the OPT applied to exercise.

**Self-Efficacy**

Exercise is proven to have an antidepressant effect in clinical depression. Self-efficacy is one mechanism proposed to explain this effect, being an important factor for mood benefits to occur (Bodin & Martinsen, 2004).

Self-efficacy for exercise refers to a very important psychological mechanism that is based on perceptions of effort and the confidence of individuals in completing a task. There are multiple levels of these perceptions, from the pre-exercise self-efficacy, self-efficacy during exercise and the post-exercise self-efficacy. Bandura (1986) hypothesized
a reciprocal relationship between self-efficacy and affect, therefore, pre-exercise self-efficacy would predict affect, and affect would predict post-exercise self-efficacy. On the other hand, self-efficacy is also related to predictors of depression, as people with low efficacy to stop negative thoughts have higher incidence of depression. Therefore, self-efficacy in our case has a dual capacity, and understanding its dynamic nature allows us to better relate affect and perceptions of effort or even more general, perceptions of various tasks in relation to mental health.

Although there is need for more research on this subject, it is positive to notice that there are potential mechanisms and theories that can explain the benefits of exercise on mental health. This will lead to a better acceptance of exercise as a powerful treatment for mental health patients and new ways to increase the use of exercise as a therapeutic method.

We conclude this section with two recent reviews of the mechanisms underlying the exercise-mental health connecting structure.

A recent review paper by Ernst Olson, Pinel, Lam and Christie (2006) focused on the physiological mechanism that underlies the relationship between exercise and depression. A multitude of studies have shown the beneficial effect of exercise in the treatment of depression, and only a small portion of them have gone below the surface to look for the mechanisms that explain this relationship. The authors mention that the most intriguing hypothesis relates exercise and major depressive disorder through the adult
neurogenesis in hippocampus (one of only two regions of the brain with reported adult neurogenesis). Although the authors found no direct link between depression and adult neurogenesis, they noticed three correlative observations: smaller hippocampus in depressed patients, antidepressive medication increases adult neurogenesis, and the latency period of the antidepressants coincides with the time it takes the new neurons to become functional. Finally, the authors evaluated different alternative mechanisms that stand between exercise and neurogenesis and looked for molecules that are affected by exercise and have an effect on neurogenesis. The selected molecules are beta-endorphins, vascular endothelial growth factor, brain-derived neurotrophic factor (BDNF) and serotonin. Each of these molecules could act independently or together, as each of them delivers certain functions as mediators of the effects of exercise on adult neurogenesis. Beta-endorphins and serotonin have a role in the birth of new neurons, while the vascular endothelial growth factor and the brain-derived neurotrophic factor help them survive. The authors conclude that the hypothesized mechanism is intriguing but more qualitative and quantitative research is needed to identify its operation and the conditions for its functionality. Due to the nature of these molecules, it is not straightforward how to study this mechanism in humans, and a possible limitation is the fact that the results are inferred from studies on animals (primarily rats).

Dishman and colleagues (2006) reviewed the neurobiology of exercise, looking at the most often hypothesized mechanisms for the effect of exercise on mental health. The
authors reviewed the metabolic and neurochemical pathways among skeletal muscle, the spinal cord, and the brain as possible processes of the exercise effect on the central nervous system. Exercise has an effect on both the cognitive and neurotrophic functions of the brain and the biology of these effects could be linked to the BDNF, norepinephrine alteration, or other molecules and brain processes. The review concluded with limitations or methodological issues, among which they mention the use of animal models, the variability in physical activity stimulus (training length - acute vs. chronic, mode, intensity, duration) and future research directions (centered around the central nervous system’s response to exercise).

SUMMARY

Exercise is an effective, simple and inexpensive approach to reduce and alleviate symptoms of depression (Martinsen, 2000). Adherence to regular exercise is a problem and more so for those suffering from depression. It is therefore important to understand people’s response to exercise and also the impact of different exercise intensities on psychological affect. More research is needed to find out the mode, intensity and frequency of exercise sessions that are associated with the most health benefits and in particular the psychological responses (mood, feeling states). The opponent process theory helps us study the benefits of exercise over a relevant period of time (from before the exercise session starts until all the psychological benefits are exhausted). Mechanisms
and theories are very important at this stage, when the correlation between exercise and improved mental health is not debated but not completely explained either.

There are some limitations/issues in the context of the literature on exercise and mental health. Many studies have been conducted on asymptomatic normal populations (Petruzzello, 1991). This large variation in diagnosis might explain the large variation in results. Also, using the same diagnostic systems would make it easier to compare results across studies. Several instruments have been developed to measure the level of depression. The Beck Depression Inventory (BDI) is a commonly used instrument to identify cases or patients in population studies. In some exercise intervention studies, the score on such scales is used as the only means of classification of a given patient, and no formal diagnoses are made. According to Martinsen (2001), this is not satisfactory, as it makes it difficult to generalize the results from these studies. Also, there are some subtypes of depression (e.g. bipolar disorder) that have a particularly strong genetic linkage. Because of this strong genetic linkage, it is unlikely that exercise could be a single treatment modality for these subtypes of depression (Dunn 2001).
CHAPTER 3
METHODS

STUDY DESIGN

This study is a counterbalanced within subjects experimental design with two within subjects factors: intensity and time [2 (intensity: moderate and high) X 8 (time: baseline, end of five minutes during the exercise session, middle of the exercise session, 5 minutes before end, at the end of the test and at 5, 15 and 30 minutes post test)]. Each participant was exposed to both treatments but in a random order. The participants picked a number (one or two) written on slips of paper: one represents the moderate intensity session; two represents the high intensity session. For the second session, the participants exercised at the remaining intensity. This accounts for the randomization of the sessions. For the third session, participants had the choice of picking one of the two intensities (moderate or high). Permission to conduct the study was obtained from The Institutional Review Board, Office of Responsible Research Practices, of the Ohio State University.
PARTICIPANT SELECTION

All participants were volunteers recruited from The Ohio State University (OSU) Community through flyers (Appendix A) and word of mouth.

To compensate the participants for their time and effort, a $20 incentive payment was provided to participants in this investigation. The payment was pro-rated across visits with a $5 payment provided after each session.

The inclusion criteria for the study were: (a) At least mildly depressed; (b) Female; (c) Sedentary; (d) Ages between 18-50; (e) BMI<32 (not obese); (f) Not pregnant or nursing; (g) If using medications for depression, participants should be on the medications for more than three weeks; (h) No physical contraindications to vigorous exercise (e.g., orthopedic problems); (i) non-smoker; (j) pre-menopausal. All potential participants in this study were females, between ages of 18-50 years.

In order to participate in the study volunteers had either a current diagnosis of depression or felt they were coping with mild to moderate depressive symptoms. Depressive symptoms were evaluated using The Beck Depression Inventory (BDI-II) (Appendix B). The cutoff score guidelines are as follows: 0-13 minimal; 14-19 mild; 20-28 moderate; 29-63 severe (BDI-II Manual, 1996). Only women with BDI –II scores indicating at least mild depression symptoms (i.e. 13-28) were included in the study. It is
agreed that potential participants who responded to item #9 on the BDI-II with a score of 2 or 3 (2 – “I would like to kill myself”; 3 – “I would kill my self if I had a chance”) would be immediately referred to their current therapist or another mental health professional.

Potential participants were required to have a body mass index (BMI) less than 32. BMI was calculated by dividing weight in kilograms by height in meters squared. Demographic information and medical history will be assessed at the beginning of the study via questionnaires (Appendix C). Medical clearance from the participant’s physician was also required for participants to take part in the study (Appendix D). Pregnancy screening for all potential participants was addressed in the medical history questions (Appendix C).

All volunteers had to have been sedentary to be eligible to participate in the study. This was determined by responses to Exercise Stage of Change Questionnaire (Appendix E) and “Godin Leisure-Time Exercise Questionnaire” (Appendix F). Stage of change model, also called transtheoretical model of behavior change, is a general model of intentional behavior change that includes a temporal component as a critical factor in describing and predicting behavior (Buckworth & Dishman, 2001). Participants have to report being in one of the inactive stages (precontemplation: individuals are inactive and have no intention to start exercising; contemplation: individuals are also inactive, but they intend to start regular exercise within the next six months), to be eligible for the
study. Regular exercise was defined as “exercise regularly, that is, three or more times each week for at least 20 minutes each time.”

The Leisure-Time Exercise Questionnaire (LTEQ) (Godin, Jobin, & Bouillon, 1986) was used to support the sedentary status determined through the stage response. The Leisure-Time Exercise Questionnaire is a self-report, three-item scale that assesses leisure-time exercise. Respondents are asked to recall the number of exercise sessions at mild, moderate and strenuous activity undertaken within a typical week. The frequency of mild exercise is multiplied by three, moderate by five and strenuous by nine and the weekly leisure activity score is calculated by summing the products of the separate components. A high score represents a greater activity level. Only the volunteers with weekly leisure activity score less than 15 within the last 6 months were included in the study. This questionnaire has adequate reliability and validity (Jacobs, Ainsworth, Hartman, & Leon, 1993). Moreover, the validity of “Godin Leisure-Time Exercise Questionnaire” compares favorably with other simple techniques of predicting fitness.
Maximal oxygen consumption ($\text{VO}_{2\text{max}}$) – To prescribe the two exercise intensities (moderate and high) we estimated $\text{VO}_{2\text{max}}$ using Bruce’s treadmill protocol (Chahine, Lowery, & Bauerlein, 1993), which estimates aerobic capacity from the peak treadmill speed and grade, according to the following graph (Figure 3.1) and formula:

![Figure 3.1 Bruce treadmill protocol showing progressive stages and the corresponding aerobic requirement](image-url)
For sedentary women the formula to estimate the maximal aerobic capacity is:

$$VO_{2\text{max}} = 14.8 - (1.379 \times T) + (0.451 \times T^2) - (0.012 \times T^3)$$

The test took place at the Ohio State University in the Exercise Physiology Laboratory in Physical Activity & Educational Services building.

**Exercise intensity** – Exercise intensity is the independent variable in this study. There are two levels: moderate and high intensity. The pilot study showed that 40% and 70% of VO$_{2\text{max}}$ provide the widest response spread with the minimum spread between intensities. Once the moderate and the high intensity were defined, they were transformed into METs values (MET=VO$_2$ in ml kg/min divided by 3.5ml/kg/min) and then into a grade and speed for treadmill exercise (according to Appendix D, Table D3, ACSM Guidelines for Exercise Testing and Prescription).

Instead of using time as the constant variable, we used the total volume of work (kcal expanded) as the constant variable so that the total volume of work between exercise conditions was equated. All participants expended 150 kcal during each session.

Example: A participant reaches 9 min, so according to the graph the maximal speed is 3.4 mph and the incline 14%. The person’s weight was 60kg.

- $VO_{2\text{max}} = 14.8 - (1.379 \times T) + (0.451 \times T^2) - (0.012 \times T^3)$
- 40% $VO_{2\text{max}} = 12.06$ ml/kg/min $= .728$ l/min $= 3.64$ kcal/min
- 70% $VO_{2\text{max}} = 21.12$ ml/kg/min $= 1.27$ l/min $= 6.37$ kcal/min
■ 40% VO\textsubscript{2max} \rightarrow 3 \text{ METs} \rightarrow 3.2 \% & 2 \text{ mph speed}

■ 70% VO\textsubscript{2max} \rightarrow 7 \text{ METs} \rightarrow 8.4 \% & 2.6 \text{ mph speed}

■ **METABOLIC CALCULATIONS**

■ VO\textsubscript{2} \text{ ml/kg/min} = \text{ VO\textsubscript{2} l/min} \times \frac{1000}{\text{ (body mass in kg) }}

■ Caloric expenditure in kcal/min = 5 \times \text{ VO\textsubscript{2} in l/min}

■ MET=\text{ VO\textsubscript{2} in ml/kg/min/3.5ml/kg/min}

■ **CONCLUSIONS**

■ 40% VO\textsubscript{2max}: 41 \text{ min on treadmill @ above grade and speed}

■ 70% VO\textsubscript{2max}: 24 \text{ min on treadmill @ above grade and speed}

For each participant, the duration of the exercise session at each of the two intensities is fixed, based on the proportional MET measures. The parameters on the treadmill are not unique. There are multiple combinations of speed and grade that are associated with the same VO\textsubscript{2} measure. To avoid any bias in selecting these parameters, we designed an algorithm that uniquely assigns them to VO\textsubscript{2}, with two restrictions: speed is not faster than 3.5 mph (i.e., walking, not running) and the curves for speed and grade are smooth, that is, they are following the diagonal of all possible values. The following graphs (Figures 3.2 and 3.3) describe the selections, which are based on the following transformation:

VO\textsubscript{2} = 0.1(speed) + 1.8 (speed) (fractional grade) + 3
For example, if VO₂ is 22, then the speed is 2.7 mph and the grade is 8.6%
Ratings of Perceived Exertion - Rate of perceived exertion (RPE) can best be defined as the act of detecting and interpreting sensations arising from the body during physical exercise. The concept was first described by Borg in 1962 and has since become an important component of exercise psychology and a means of prescribing training regimens. Participants were familiarized with Borg’s 6-20 category scale (Appendix G). It is an ordinal scale with values from 6 (no exertion at all) to 20 (maximal exertion) used to assess how heavy and strenuous the activity feels to them overall. Verbal anchors are provided to standardize for comparisons across individuals and tasks. The greater the exertion felt the greater the number reported by the individual being tested. This scale increases linearly with physiological measures such as HR and VO₂ as exercise intensity increases.

Psychological Measures

Only a few studies have reported values for affect at repeated measurements post-exercise. Understanding the long-lasting effects of exercise is important, as these effects could be more beneficial than immediate effects. The resolution of these issues is important because the outcomes are likely to have implications for the prescription of exercise for psychological benefits especially in the case where one intensity is associated with longer lasting benefits while another is associated with strongest immediate effects.
Therefore, it is important that exercise induced affect is measured not only immediately after exercise, but that repeated measurements post-exercise are included in order to capture the continual changes in affect that are expected according to Opponent Process Theory. Researchers need to be sure they are including enough measurements pre, during and post-exercise, because of the dynamic nature of the affect changes when exposed to the exercise stimulus. This comprises one of the biggest challenges when studying this theory, as affect measures cannot be easily assessed and are almost impossible to measure on a continual basis.

For our study we had three measures of psychological responses, which were assessments of self-efficacy (SE), affective reaction [e.g., pleasure, arousal, and dominance measured using the Self-Assessment Manikin (SAM)] and enjoyment. Measurement was repeated at eight different points in time shown in Table 3.1. During the exercise session, we measured SAM at the end of the first 5 min, in the middle of the exercise session, 5 min before the end of the exercise session and at the end of the exercise session (right after the treadmill stopped while the participant was still on the treadmill).
Table 3.1 Time measurements for SAM, Enjoyment and Self-Efficacy

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>During</th>
<th>5 min post-exercise</th>
<th>15 min post-exercise</th>
<th>30-min post-exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.SAM 2.SE</td>
<td>1.SAM (at the end of the first 5 min, middle, 5 min before end, end test)</td>
<td>1.SAM 2.SE 3.Enjoyment</td>
<td>1.SAM 2.SE 3.Enjoyment</td>
<td>1.SAM 2.SE 3.Enjoyment</td>
</tr>
</tbody>
</table>

**Self-Assessment Manikin (SAM)** The Self-Assessment Manikin (SAM) is a non-verbal pictorial assessment technique based on a continuous nine-point scale that directly measures the pleasure, arousal, and dominance associated with a person's affective reaction to a wide variety of stimuli. Because we want to measure affect pre-, during-, and post-exercise, SAM is particularly convenient. During exercise, the participant can point to the figure that best describes her feeling at the moment. SAM consists of three sets of five figures each. To get the nine-point scale, participants can choose a point below a figure or a point in between any consecutive pair of figures. Before the first exercise session, the instructions on administering the SAM were read to the each participant.

Mehrabian and Russell (1977) described a three-dimensional approach as a way to assess emotional responses. They developed the pleasure, arousal and dominance (PAD) model and showed that any emotion can be described in terms of three
independent and bipolar dimensions: pleasure-displeasure, degree of arousal and dominance-submissiveness. SAM visually represents the three PAD dimensions and was designed as an alternative to the sometimes-cumbersome verbal-report measures. The correlations between scores obtained using SAM and those obtained from PAD were very high for both pleasure (0.94) and arousal (0.94) and smaller but still satisfactory for dominance (0.66) (Lang, 1985). Moreover, the use of SAM is extremely efficient and convenient because it only takes participants 15 seconds to complete it. This avoids response fatigue and allows numerous stimuli to be measured in a short amount of time or repetitively over a short period of time. To avoid a response bias that might occur with numerical anchor points, nine evenly spaced circles were placed under the cartoon representations of the three dimensions. The participant was asked to point to the place (on a scale from 1 to 9) on each of the three dimensions that corresponded with how she was feeling at the moment (Appendix H).

Enjoyment - To measure enjoyment of the exercise session, we used “Physical Activity Enjoyment Scale” (PAES) (Kendzierski & DeCarlo, 1991; Appendix I). Its purpose is to measure the extent to which an individual enjoys exercise at a given point in time. The PAES scale consists of 12 statements with a 7-point semantic differential format. A summary score is computed by summing all 12 items. Three of the 12 items are reverse ordered. Users of PAES are to rate how they feel at the moment about the physical
activity they have been undertaking. An example of a bipolar objective is “I feel bored” – “I feel interested”. The higher the summary score added from PAES the more the individual enjoys doing that activity and the lower the score the less the individuals enjoy doing that activity.

**Self-Efficacy** - According to Bandura, “perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives” (Bandura, 1994)” Self efficacy is determined by our perception of the ability to reach a certain goal. Higher self-efficacy is associated with higher goals and optimism, while a low sense of self-efficacy is linked to anxiety and pessimism. People with high self-efficacy choose to perform more challenging tasks and they invest more effort and try harder to achieve their goals than people with lower self-efficacy. Moreover, when they fail, people with high self-efficacy recover more quickly and are more likely to still try to reach their goals (Schwarzer, 1992). The exercise self-efficacy scale represented the participant’s confidence in being able to successfully complete 5-min incremental segments (up to the total required time in order to expend 150 calories) of the exercise session at a moderate or vigorous pace. Because the scale is a function of exercise duration, it will not be unique across all participants and across the exercise sessions at high and moderate intensity. We used a scale with 5-min increments and measured sequentially the beliefs of participants for each incremental
duration (e.g., from 5 min until the total duration of the exercise session). Each participant had a longer scale for the lower intensity, because she had to expend the same amount of kcal as in the case of the high intensity and therefore the duration of the moderate intensity session was longer than the duration of the high intensity session. Participants indicated their degree of confidence in completing the task on a 100-point percentage scale with 100% completely certain and 0% highly uncertain. The final score is the average of each response, thus the sum of each response divided by the total number of questions. Because of the bias given by the different increments of time, an alternative measure was captured, which was the response for the last question in the questionnaire (Appendix J).

TIMELINE

Prior to the experiment, each participant completed an informed consent and medical history form. Each participant participated in three exercise sessions on the treadmill (see Appendix K for data sheet collection format).

Visit 1 - Goals, objectives, and procedures of the study were reviewed and explained. The participant filled out an informed consent and the questionnaires to assess her normal physical activity (“Godin Leisure-Time Exercise Questionnaire” and Exercise Stage of Change Questionnaire) and level of depressive symptoms according to the BDI-II. If a
volunteer was physically active (criteria from Godin and Exercise Stage of Change) and/or scores less than 14 on the BDI-II, she will be thanked and informed that she is ineligible for the study. Demographic information was also obtained. The participants that met the inclusion criteria performed the Bruce protocol in order to determine their estimated $\text{VO}_{2\text{max}}$.

Visit 2, 3 – The order of the treatment was counterbalanced. Participants picked a number (one or two) written on slips of paper: one represented the moderate intensity session; two represented the high intensity session;

Visit 4 – the participants were asked to pick one of two previous intensities.

In addition, RPE was taken for each session (at rest and every 5 min during exercise).

DATA ANALYSIS

The sample size was selected based on power calculations to find a significant difference in the pleasure-displeasure. According to Cohen Power tables and assuming a moderate effect and a moderate correlation between measures, the estimated sample size was 18. Significance was set $a \text{ priori}$ at $p < .05$. The reliability was computed for different groups of variables using Cronbach’s alpha for which $\geq .70$ is considered acceptable (Cohen, 1988). For statistical analysis, we used multivariate analysis of variance.
In order to capture the effect of exercise over various time segments, the change scores were defined for variables that were measured over time. The change score were computed in reference to baseline values and also between consecutive measurements.

For consistency in notation, the change score for SAM variables (P=Pleasure, A=Arousal, D=Dominance) was defined as the older score subtracted from the newer score, at different combinations of measurement times. The notation follows the convention:

\[\text{[intensity]}\{\text{SAM}\}\{\text{affect}\}\{\text{Diff}\}\{\text{period}\}\]

where [intensity] is either m (moderate) or h (high), [affect] is P (Pleasure), A (Arousal) or D (Dominance) and [period] is the period of time over which we define the change.

The timeline of measurement was designed as follows:

For each SAM construct, we began the analysis with descriptive scores. Repeated Measures ANOVA determined the significance of the main effect for time and intensity
and the significance of the interaction between time and intensity. Repeated Paired t-tests were then used to determine the segments with significant difference between the two exercise intensities. One Sample t-tests were run to determine the effect of exercise for each of the two intensity conditions and to determine the time segments where the change in scores was significant.

Greenhouse-Geisser degrees of freedom corrections were used when the assumption of Sphericity was violated.
CHAPTERS 4

RESULTS

This chapter presents the results of the statistical analyses of data related to each of the research hypotheses. The analysis was conducted using Statistical Package for the Social Sciences (SPSS) version 15 for Windows (SPSS, Inc., Chicago, IL, 2006).

PARTICIPANT CHARACTERISTICS

Participants were recruited from The Ohio State University during the months of March and April 2006. A total of 55 women expressed interest in participating in the study. Thirty-seven did not satisfy the inclusion criteria. Most of them were excluded because of low BDI scores, obesity and/or because they were physically active. Eighteen women met the inclusion criteria and were evaluated during this 2-month period.

The race distribution of the participants was as follows: 72.2% Non-minority, 5.6% African-Americans, 5.6% American Indians and 16.7% Asian. The distribution of the participants reflects greater participation of minorities compared to the community’s distribution from where the participants were recruited (OSU campus: 86.3% Non-minority, 6.9% African Americans, 4.6% Asian Americans, 1.8% Hispanic and 0.4% American Indians). Refer to table 4.1 for the descriptive statistics of the sample.
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>23.6</td>
<td>6.00</td>
<td>18 - 41</td>
</tr>
<tr>
<td>Body mass index (kg/m$^2$)</td>
<td>24.07</td>
<td>3.56</td>
<td>19 - 31</td>
</tr>
<tr>
<td>VO$_{2\text{max}}$ (ml/kg/min)</td>
<td>37.39</td>
<td>6.59</td>
<td>23.7 - 50.1</td>
</tr>
<tr>
<td>Depression Score (BDI-II)</td>
<td>16.28</td>
<td>3.44</td>
<td>13 - 26</td>
</tr>
</tbody>
</table>

Table 4.1 Descriptive statistics for the study group ($N=18$)

Primary Purpose

The purpose of the study was to investigate the relationship between a and b processes from the Opponent Process Theory during acute exercise in sedentary depressed women. Specifically, the study was designed to examine if a more pronounced negative affective response during a single bout of exercise (a process) generates a stronger and longer lasting improvement in affect post-exercise (b process) when equating for the total energy expended during the exercise session.
Hypothesis A

A. During the exercise session, the negative affect has a higher magnitude for the high intensity than for the moderate intensity.

OPT a-process

Pleasure

The first hypothesis to be tested was whether during the exercise session, the negative affect had a higher magnitude for the higher intensity than for the moderate intensity.

We first look at the descriptive statistics for SAMP (Table 4.2) during the a-process (i.e., during exercise):

<table>
<thead>
<tr>
<th>Intensity</th>
<th>SAMP_0</th>
<th>SAMP_1</th>
<th>SAMP_2</th>
<th>SAMP_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>6.33 ± 2.02</td>
<td>5.94 ± 1.98</td>
<td>5.89 ± 2.05</td>
<td>5.67 ± 2.02</td>
</tr>
<tr>
<td>High</td>
<td>6.06 ± 1.21</td>
<td>4.72 ± 1.36</td>
<td>4.50 ± 1.61</td>
<td>4.39 ± 1.72</td>
</tr>
</tbody>
</table>

Table 4.2 Mean and standard deviation for SAM Pleasure during a process.

Note. SAMP_0 = baseline, SAMP_1 = 5 min into the session; SAMP_2 = middle; SAMP_3 = 5 min before end of session.
Repeated Measures ANOVA

A 2x3 Repeated Measured ANOVA design (2 intensities: moderate and high; 3 change scores: 0-1, 1-2, 2-3) showed a significant main effect of time, $F(2,34)=6.416$, $\eta^2=.274$, $p=.004$ and intensity, $F(1,17)=8.052$, $\eta^2=.321$, $p=.011$. The interaction between time and intensity was not significant, $F(2,34)=2.597$, $\eta^2=.133$, $p=.089$.

The Tests of Within-Subjects Contrasts showed that the trend for the main effect of time is linear, $F(1,17)=11.29$, $\eta^2=.399$, $p=.004$.

Paired t-tests

Repeated paired t-tests were run to determine the time segments where the change scores differ significantly between high and moderate intensity. The paired t-test yielded that the higher intensity is associated with a significantly greater drop in pleasure compared to the moderate intensity from pre-test to the first measurement during exercise ($t=-3.449$, $p=.003$), from pre-test to the second measurement during exercise ($t=-3.828$, $p=.001$) and from pre-test to the third measurement during exercise ($t=-2.838$, $p=.011$). The difference in effects for consecutive measurements during exercise, from the first to the second ($t=-.470$, $p=.644$) and from the second to the third ($t=.416$, $p=.682$) are not significant (see Table 4.3).
Table 4.3. Mean and standard deviation of the difference in SAM change scores from moderate to high intensity (a-process)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Time segments</th>
<th>0-1</th>
<th>1-2</th>
<th>2-3</th>
<th>0-2</th>
<th>0-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleasure</td>
<td>.94 ± 1.16**</td>
<td>.17±1.50</td>
<td>-.11±1.13</td>
<td>1.11±1.23**</td>
<td>1.00±1.49*</td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td>-.22 ± 1.47</td>
<td>-.61±.84**</td>
<td>-1.05±.72**</td>
<td>-.83±1.40*</td>
<td>-1.88±1.57**</td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td>2.05±1.69**</td>
<td>.61±1.24</td>
<td>.06±.99</td>
<td>2.67±1.94**</td>
<td>2.72±1.96**</td>
<td></td>
</tr>
</tbody>
</table>

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

Therefore, the higher intensity is associated with significantly greater drop in pleasure from baseline to each measurement point during exercise. The drop in pleasure from pre-test to the first measurement drives these results, as the next consecutive effects are not significantly different between the two intensities.

One sample t-test

A series of one sample t-tests comparing level of pleasure at the three points during exercise to baseline levels (SAMP_0) and the levels between consecutive points during exercise yielded that the decrease in pleasure during the a-process is significant for the moderate intensity from time 0 to time 3 ($t=2.38, p=.029$) (see table 4.4).
### Table 4.4. Mean and standard deviation of SAM change scores for moderate intensity (a-process)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>0-1</th>
<th>1-2</th>
<th>2-3</th>
<th>0-2</th>
<th>0-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleasure</td>
<td>-0.39±1.03</td>
<td>-0.05±.72</td>
<td>-0.22±.73</td>
<td>-0.44±1.14</td>
<td>-0.67±1.18*</td>
</tr>
<tr>
<td>Arousal</td>
<td>1.06±1.21**</td>
<td>0.33±.59*</td>
<td>-0.22±.64</td>
<td>1.39±1.14**</td>
<td>1.16±1.46**</td>
</tr>
<tr>
<td>Dominance</td>
<td>0.22±.87</td>
<td>0.33±.90</td>
<td>0±.76</td>
<td>0.55±1.33</td>
<td>0.55±1.33</td>
</tr>
</tbody>
</table>

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

For the high intensity the decrease in pleasure was significant from time 0 to time 1 ($t=5.497$, $p=.000$), from time 0 to time 2 ($t=4.63$, $p=.000$) and from time 0 to time 3 ($t=4.20$, $p=.001$) (see table 4.5).
Table 4.5. Mean and standard deviation of SAM change scores for high intensity (a-process)

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

The change score comparison by intensity and time is shown in the following graph (Figure 4.1).

![Pleasure change during a-process](image)

Figure 4.1. Change scores for SAM Pleasure during a-process

*Note.* M = moderate intensity; H = high intensity
Arousal

We first look at the descriptive statistics for arousal during the a-process (i.e., during exercise):

<table>
<thead>
<tr>
<th>Intensity</th>
<th>SAMA_0</th>
<th>SAMA_1</th>
<th>SAMA_2</th>
<th>SAMA_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>4.72 ± 2.08</td>
<td>5.78 ± 1.47</td>
<td>6.11 ± 1.41</td>
<td>5.89 ± 1.18</td>
</tr>
<tr>
<td>High</td>
<td>4.83 ±1.15</td>
<td>6.11 ± 2.08</td>
<td>7.06 ± 1.66</td>
<td>7.89 ± 1.13</td>
</tr>
</tbody>
</table>

Table 4.6 Mean and standard deviation for SAM Arousal during a process

Repeated Measures ANOVA

A 2x3 Repeated Measured ANOVA design (two intensities: moderate and high; 3 change scores: 0-1, 1-2, 2-3) showed that there is a main effect of time, $F(2, 34)= 5.043$, $\eta^2=.606$, $p=.012$ and intensity $F(1, 17)= 26.13$, $\eta^2=.229$, $p=.000$. The interaction between time and intensity is not significant, $F(2, 34)= 2.39$, $\eta^2=.124$, $p=.127$.

The Tests of Within-Subjects Contrasts show that the trend for the main effect of time is linear, ($F(0,17)=9.49$, $\eta^2=.358$, $p=.007$).
**Paired t-tests**

Repeated paired t-tests were run to determine the time segments where the change scores differ significantly between high and moderate intensity. The difference between the high intensity and the moderate intensity is not significant between pre-test and the first measurement during exercise, at 5 min \(t=0.638, p=0.532\), but higher intensity is associated with a significantly greater increase in arousal compared to moderate intensity from pre-test to the second measurement during exercise \(t=2.64, p=0.017\) and from pre-test to the third measurement during exercise \(t=5.11, p=0.000\). The difference in effects for consecutive measurements during exercise is also significant, from the first to the second \(t=3.05, p=0.007\) and from the second to the third \(t=6.17, p=0.000\) measurement during exercise (see Table 4.3). Unlike the pattern for pleasure, what drives the difference between the moderate and the high intensity occurs after the first 5 min of the exercise session, specifically the change in arousal from 5 min into the exercise to the middle, and from the middle to 5 min before the session is over.

**One sample t-test**

A series of one sample t-tests yielded that the increase in arousal during the a-process is significant for the moderate intensity from time 0 to time 1 \(t=-3.70, p=0.002\), from time 0 to time 2 \(t=-5.15, p=0.000\), from 0 to time 3 \(t=-3.38, p=0.004\) and from 1 to time 2 \(t=-2.38, p=0.029\) (see table 4.4).
For the high intensity, the increase in arousal was significant from time 0 to time 1 ($t=-4.42, p=.000$), from time 0 to time 2 ($t=-8.46, p=.000$) and from time 0 to time 3 ($t=-11.68, p=.000$), from 1 to time 2 ($t=-4.60, p=.000$), from 2 to time 3 ($t=-4.50, p=.000$) (see table 4.5).

The change score comparison by intensity and time is shown in the following graph (Figure 4.2).

![Arousal change during a-process](image)

**Figure 4.2.** Change scores for SAM Arousal during a-process

*Note.* M = moderate intensity; H = high intensity
Dominance

We first look at the descriptive statistics for dominance during the a-process (i.e. during exercise):

<table>
<thead>
<tr>
<th>Time segments</th>
<th>SAMD_0</th>
<th>SAMD_1</th>
<th>SAMD_2</th>
<th>SAMD_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>6.06 ± 2.07</td>
<td>6.28 ± 1.80</td>
<td>6.61 ± 1.94</td>
<td>6.61 ± 1.81</td>
</tr>
<tr>
<td>High</td>
<td>5.67 ± 1.87</td>
<td>3.83 ± 1.14</td>
<td>3.56 ± 1.58</td>
<td>3.50 ± 1.75</td>
</tr>
</tbody>
</table>

Table 4.7 Mean and standard deviation for SAM Dominance during a process

Repeated Measures ANOVA

A 2x3 Repeated Measured ANOVA design (two intensities: moderate and high; three change scores: 0-1, 1-2, 2-3) showed that the interaction between time and intensity is significant, $F=9.27, \eta^2 = .353, p=.001$.

Paired t-test

Because the time by intensity interaction is significant, the effect of intensity depends on the time measurement points.

Repeated paired t-tests were run to determine the time segments where the change scores differ significantly between high and moderate intensity (i.e. to determine the simple effect of intensity). The paired t-test shows that the higher intensity is associated
with a significantly higher drop in dominance from pre-test to the first measurement during exercise \((t=-5.14, p=.000)\), from pre-test to the second measurement during exercise \((t=-5.83, p=.000)\) and from pre-test to the third measurement during exercise \((t=-5.88, p=.000)\). The difference in effects for consecutive measurements during exercise is not significant, from the first to the second \((t=-2.09, p=.052)\) and from the second to the third \((t=-2.36, p=.816)\) measurement during exercise (see Table 4.3).

**One sample t-test**

A series of one sample t-tests showed no significant change between any time segments for the moderate intensity (see table 4.4).

For the high intensity condition the decrease in dominance was significant from time 0 to time 1 \((t=5.31, p=.000)\), from time 0 to time 2 \((t=5.86, p=.000)\) and from time 0 to time 3 \((t=5.81, p=.000)\) (see table 4.5).

The change score comparison by intensity and time is shown in the following graph (Figure 4.3).
Dominance change during a-process

Figure 4.3. Change scores for SAM Dominance during a-process

Note. M = moderate intensity; H = high intensity

Hypothesis B

After exercise, the positive affect reaches higher levels and it is longer lasting for the higher intensity than for the moderate intensity.

OPT b-Process

Pleasure

We first look at the descriptive statistics for SAMP (Table 4.8) during the b-process (i.e., after exercise):
The baseline measure for the b-process is the pleasure score at the end of the exercise session. We again define the effect as the difference in scores between different time measurements.

*Repeated Measures ANOVA*

Results from Repeated Measures ANOVA with a 2X3 design (2 intensities: moderate and high; 3 change scores: 4-5, 5-6, 6-7) show a main effect of intensity, $F(1,17)=30.76$, $\eta^2=.64$, $p=.000$ and time, $F(2,34)=6.021$, $\eta^2=.26$, $p=.006$. The interaction between time and intensity is not significant, $F(2,34)=.037$, $\eta^2=.002$, $p=.964$.

From the Tests of Within-Subjects Contrasts we obtain that the effect of $F(1,17)=30.76$, $\eta^2=.341$, $p=.000$, has a linear trend.

<table>
<thead>
<tr>
<th>Time segments</th>
<th>SAMP_4</th>
<th>SAMP_5</th>
<th>SAMP_6</th>
<th>SAMP_7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>6.11 ±1.99</td>
<td>6.61 ±1.75</td>
<td>6.67 ±1.82</td>
<td>6.50 ±1.82</td>
</tr>
<tr>
<td>High</td>
<td>5.28 ±2.08</td>
<td>6.61 ±1.24</td>
<td>7.39 ±1.29</td>
<td>7.49 ±.80</td>
</tr>
</tbody>
</table>

Table 4.8 Mean and standard deviation for SAM Pleasure during b process
**Paired t-test**

Repeated paired t-tests were run to determine the time segments where the change scores differ significantly between high and moderate intensity. The paired t-tests show that the increase in pleasure during the b-process is significantly higher for the high intensity compared with the moderate intensity for all time periods \((p<.05)\), from baseline to 5, 15 and 30 min after exercise and from 5 to 15 and from 15 to 30 min post exercise (see table 4.9).

<table>
<thead>
<tr>
<th>Time segments</th>
<th>4-5</th>
<th>5-6</th>
<th>6-7</th>
<th>4-6</th>
<th>4-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension</td>
<td>Pleasure</td>
<td>Arousal</td>
<td>Dominance</td>
<td>Pleasure</td>
<td>Arousal</td>
</tr>
<tr>
<td>4-5</td>
<td>-.83±1.58*</td>
<td>.38±1.64</td>
<td>-.55±1.82</td>
<td>-.72±.82**</td>
<td>.38±1.75</td>
</tr>
<tr>
<td>5-6</td>
<td>-.72±1.36*</td>
<td>.38±.84</td>
<td>-.27±.95</td>
<td>-.72±1.36*</td>
<td>.38±.84</td>
</tr>
<tr>
<td>6-7</td>
<td>-1.55±1.68**</td>
<td>.77±.94**</td>
<td>-.94±2.07</td>
<td>-1.55±1.68**</td>
<td>1.16±1.04**</td>
</tr>
<tr>
<td>4-6</td>
<td>-2.27±1.74**</td>
<td>1.16±1.04**</td>
<td></td>
<td>-2.27±1.74**</td>
<td></td>
</tr>
<tr>
<td>4-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.9. Mean and standard deviation of the difference in SAM change scores from moderate to high intensity (b-process)

* \(p < .05\)

** \(p < .01\)

In order to test if the increase in pleasure was longer lasting for the high intensity we compared the pre-test score with the scores at 5, 15 and 30 min post-test. Paired t-test for SAM pleasure shows that the increase from 0 to 6 \((t=2.915, p=.010)\) and the increase
in pleasure from 0 to 7 \((t=5.733, p=.000)\) are significantly higher for the high intensity compared to the moderate intensity. Also, the increase in pleasure from pre-test to post test \((5, 15 \text{ and } 30 \text{ min})\) is not significant for the moderate intensity; after the bout at the high intensity, the increase in pleasure from baseline is significant at 5 min \((t=-2.15, p=.046)\), at 15 min \((t=-5.50, p=.000)\) and at 30 min \((t=-6.51, p=.000)\).

One sample t-test

A series of one sample t-tests showed that for the moderate intensity, the increase in pleasure was significant from time 4 to time 5 \((t=-2.69, p=.015)\) and from time 4 to time 6 \((t=-2.55, p=.02)\) (see table 4.10).

<table>
<thead>
<tr>
<th>Time segments</th>
<th>4-5</th>
<th>5-6</th>
<th>6-7</th>
<th>4-6</th>
<th>4-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleasure</td>
<td>.05±.78*</td>
<td>.05±.47</td>
<td>-0.16±.78</td>
<td>.55±.92*</td>
<td>.38±1.28</td>
</tr>
<tr>
<td>Arousal</td>
<td>-.22±.42*</td>
<td>-.38±1.09</td>
<td>-0.16±.51</td>
<td>-.61±.20*</td>
<td>-.77±1.21*</td>
</tr>
<tr>
<td>Dominance</td>
<td>0.56±.78**</td>
<td>1.11±.58</td>
<td>.00±.34</td>
<td>0.56±.78**</td>
<td>.56±.78**</td>
</tr>
</tbody>
</table>

Table 4.10. Mean and standard deviation of SAM change scores for moderate intensity (b process)

* \(p < .05\)
** \(p < .01\)

For the high intensity the increase in pleasure was significant from time 4 to time 5 \((t=-3.88, p=.001)\), from time 4 to time 6 \((t=-5.03, p=.000)\), from time 4 to time 7 \((t=-
6.73, \( p = .000 \), from time 5 to time 6 (\( t = -.75, \ p = .002 \)) and from time 6 to time 7 (\( t = -2.55, \ p = .02 \)) (see table 4.11).

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Time segments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4-5</td>
</tr>
<tr>
<td>Pleasure</td>
<td>1.33±1.45**</td>
</tr>
<tr>
<td>Arousal</td>
<td>-.61±1.61</td>
</tr>
<tr>
<td>Dominance</td>
<td>1.11±1.40**</td>
</tr>
</tbody>
</table>

Table 4.11. Mean and standard deviation of SAM change scores for high intensity (b process)

* \( p < .05 \)
** \( p < .01 \)

The effect by intensity and time is summarized in the following graph:
Figure 4.4. Change scores for SAM Pleasure during b-process

Note. M = moderate intensity; H = high intensity

Arousal

We first look at the descriptive statistics for SAMA (Table 4.12) during the b-process:

<table>
<thead>
<tr>
<th>Time segments</th>
<th>Intensity</th>
<th>SAMA_4</th>
<th>SAMA_5</th>
<th>SAMA_6</th>
<th>SAMA_7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moderate</td>
<td>5.83 ±1.34</td>
<td>5.61 ±1.46</td>
<td>5.22 ±1.70</td>
<td>5.06 ±1.80</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>7.33 ±.97</td>
<td>6.72 ±1.32</td>
<td>5.94 ±1.35</td>
<td>5.39 ±1.24</td>
</tr>
</tbody>
</table>

Table 4.12 Mean and standard deviation for SAM Arousal during b process
Repeated Measures ANOVA

Repeated Measures ANOVA with a 2X3 design (2 intensities: moderate and high; 3 change scores: 4-5, 5-6, 6-7), shows a main effect of intensity, $F(1,17)=22.51$, $\eta^2=.57$, $p=.000$. The effect of time, $F(2,34)=.296$, $\eta^2=.017$, $p=.674$ and the interaction between time and intensity, $F(2,34)=0$, $\eta^2=.000$, $p=1$, are not significant.

Paired t-test

Repeated paired t-tests were run to determine the time segments where the change scores differ significantly between high and moderate intensity. The paired t-test shows that the higher intensity is associated with a significantly greater drop in arousal compared to moderate intensity from time 4 to time 6 ($t=-3.5$, $p=.003$) and from time 4 to time 7 ($t=-4.75$, $p=.000$) (see Table 4.9).

One Sample t-test

A series of one sample t-tests showed that for the moderate intensity the decrease in arousal was significant from time 4 to time 5 ($t=2.20$, $p=.042$) and from time 4 to time 6 ($t=2.17$, $p=.045$) and from time 4 to time 7 ($t=2.71$, $p=.015$) (see table 4.10).

For the high intensity the decrease in arousal was significant from time 4 to time 6 ($t=6.02$, $p=.000$), from time 4 to time 7 ($t=8.26$, $p=.000$) (see table 4.11).

The effect by intensity and time is summarized in the following graph (Figure 4.5):
Figure 4.5. Change scores for SAM Arousal during b-process

Note. M = moderate intensity; H = high intensity

Dominance

We first look at the descriptive statistics for SAMD (Table 4.2) during the b-process (i.e., after exercise):

<table>
<thead>
<tr>
<th>Time segments</th>
<th>Intensity</th>
<th>SAMD_4</th>
<th>SAMD_5</th>
<th>SAMD_6</th>
<th>SAMD_7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moderate</td>
<td>6.78 ± 1.77</td>
<td>7.22 ± 1.67</td>
<td>7.33 ± 1.57</td>
<td>7.33 ± 0.97</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>4.61 ± 2.17</td>
<td>5.72 ± 1.84</td>
<td>6.11 ± 1.78</td>
<td>6.39 ± 2.09</td>
</tr>
</tbody>
</table>

Table 4.13 Mean and standard deviation for SAM Dominance during b process
Repeated Measures ANOVA

Repeated Measures ANOVA with a 2X3 design (2 intensities, moderate and high and 3 change scores: 4-5, 5-6, 6-7) showed a main effect for time, $F(2,34)=10.44\ , \eta^2=.380, p=.000$. Nor the main effect of intensity, $F(1,17)=3.38, \eta^2=.17, p=.084$ or the interaction between time and intensity, $F(2,34)=0, \eta^2=.017, p=1$, were significant.

From the Tests of Within-Subjects Contrasts we obtain that the effect of time has a linear trend, $F(2,34)=17.22, \eta^2=.503, p=.001$.

Paired t-test

Repeated paired t-tests were run to determine the time segments where the change scores differ significantly between high and moderate intensity.

The paired t-test shows that the higher intensity is associated with a significantly higher increase in dominance from time 4 to time 7 ($t=2.27, p=.037$) All the other effects are not significantly different between the moderate and the high intensity (see Table 4.9).

One Sample t-test

A series of one sample t-tests showed that for the moderate intensity the increase in dominance was significant from time 4 to time 5 ($t=-3.0, p=.008$) and from time 4 to time 6 ($t=-3.0, p=.008$) and from time 4 to time 7 ($t=-3.0, p=.008$) (see table 4.10).
For the high intensity the increase in dominance was significant from time 4 to time 5 ($t=-3.34, p=.004$), from time 4 to time 6 ($t=-3.77, p=.002$), from time 4 to time 7 ($t=-3.85, p=.001$), and from time 5 to time 6 ($t=-2.36, p=.003$) (see table 4.11). The effect by intensity and time is summarized in the following graph:

![Dominance change during b-process](image)

**Figure 4.6.** Change scores for SAM Dominance during b-process

*Note.* M = moderate intensity; H = high intensity

*Pre-test to post-test comparison*

Pleasure mean scores drop during exercise (for both intensities) and then increase post exercise. Mean scores for pleasure exhibited greater magnitudes during both a-process and b-process for high compared to moderate intensity exercise session. Paired t-test for SAM showed that the increase from baseline to 30 min post-test score ($t=5.733$,


$p=.000$) is significantly greater for the high intensity compared to the moderate intensity (see Figure 4.7)

![Pleasure mean scores by intensity over time](image)

**Figure 4.7** Pleasure mean score by intensity over time

For arousal, the pattern of mean scores is reversed, as arousal increases during exercise and decreases once the exercise session ends for both moderate and high intensity (see Figure 4.8). The high intensity was associated with higher arousal across all the measurement points (for both a and b processes). The paired t-test showed that there is no significant difference between the moderate and high intensity from time 0 to time 7 ($t=.497, p=.625$)
Figure 4.8 Arousal mean score by intensity over time

Dominance patterns differ between the two intensities. For the moderate intensity, the mean dominance scores increase over time, while for the high intensity, the mean scores decrease during exercise and then recover after the exercise session ends (see Figure 4.9). The differences between the effects of the two intensities for dominance from time 0 to time 7 are not significant ($t=-1.033, p=.316$)
**Secondary purpose**

The secondary purpose of the study was to determine whether participants will pick the intensity that corresponds to higher and longer lasting positive affect after exercise. Nine women selected the moderate and nine women selected the higher intensity.

In order to test our hypothesis, we defined a new variable, Predicted Pleasure Choice, as the intensity associated with the greater increase in pleasure from baseline to 30 min post test; in other words, for each of the 18 participants, Predicted Pleasure
Choice was the high intensity if the participant had the higher increase in pleasure after the high intensity bout and the moderate intensity if the participant experienced the highest increase in pleasure after the moderate intensity bout.

Using logistic regression, we determined that the probability of selecting the high intensity does not differ between the participants with the higher increase in pleasure score for the high intensity and those with the higher increase in pleasure score for the moderate intensity from baseline to 5, 15 and 30 min post test. For the women who selected the moderate intensity, the average of the increase in pleasure score from baseline to 30 min post test during the first moderate intensity session was .22 and during the high intensity session was 2.22. Women who selected the high intensity reported average increases in pleasure scores during the moderate and first high intensity sessions of .11 and 1.56, respectively.

Similarly to Predicted Pleasure Choice, we defined Predicted Enjoyment 5 Choice, Predicted Enjoyment 15 Choice and Predicted Enjoyment 30 Choice. These variables are based on the Enjoyment total score at 5, 15 and 30 min post test.

Logistic regression showed that the participants who exhibited the higher enjoyment at 15 and 30 min after the high intensity had a significantly higher probability of selecting the high intensity as their choice for the third bout (p=.03). The higher enjoyment score at 5 min post exercise did not have a significant predictive power.
Table 4.14 summarizes the practical significance of the model, which shows that the model is 77.8% correct.

<table>
<thead>
<tr>
<th>Choice</th>
<th>Intensity with greater post-test enjoyment</th>
<th>% Intensity Match</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>For third bout</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.14 Classification Table for Choice

**Manipulation check for exercise intensity**

The mean RPE for the moderate intensity was 10.5 (range 8-12) and for the high intensity was 15.2 (range 12-17). For the moderate intensity bout, one participant reported RPE of 8, two participants RPE of 9, six participants RPE 10, four participants RPE 11 and five participants RPE 12. For the high intensity bout, one participant reported RPE of 12, three participants RPE of 13, 4 participants RPE of 15, 7 participants RPE of 16 and three participants RPE of 17.

Women who selected the moderate intensity at the third session reported RPE during the first moderate and high intensity sessions of 10.44 and 15, respectively while those who selected high intensity reported RPE during the moderate and first high intensity sessions of 10.67 and 15.44, respectively.
Other results

Enjoyment

Enjoyment was measured 5-, 15-, and 30-min post exercise.

We first look at the descriptive statistics for total enjoyment scores at 5-, 15-, and 30-min post test (Table 4.15) during the b-process (i.e., post exercise):

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Enjoyment_5</th>
<th>Enjoyment_15</th>
<th>Enjoyment_30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>60.44 ±9.27</td>
<td>60.00 ±10.15</td>
<td>59.61 ±10.61</td>
</tr>
<tr>
<td>High</td>
<td>59.44 ±10.00</td>
<td>62.72 ±11.69</td>
<td>63.11 ±11.81</td>
</tr>
</tbody>
</table>

Table 4.15 Mean and standard deviation for Enjoyment during b process

One sample T-test

There was no significant difference between the enjoyment scores from 5 to 15 min, from 15 min to 30 or from 5 to 30 min after the moderate intensity exercise session. For the high intensity session, enjoyment was significantly greater from 5 to 15 min ($t=-3.3, p=.004$) but there was no significant difference in enjoyment score from 15 to 30 min.
**Paired T-test**

The enjoyment scores for moderate intensity were not significantly different than the enjoyment scores for the high intensity at 5, 15 and 30 min post exercise.

**Self-Efficacy**

Self-efficacy was measured at pre-test and 5-, 15-, and 30-min post exercise. We first look at the descriptive statistics for average self-efficacy scores (Table 4.13):

Table 4.16 Scores for Average Self-Efficacy at pre-test and 5-, 15-, and 30-min post test (mean ± SD).

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Pre-Test</th>
<th>5 min Post</th>
<th>15 min Post</th>
<th>30 min Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>86.43 ±14.07</td>
<td>99.04 ±2.96</td>
<td>99.13 ±3.37</td>
<td>99.44 ±2.36</td>
</tr>
<tr>
<td>High</td>
<td>76.09 ±16.33</td>
<td>95.81 ±6.70</td>
<td>95.73 ±6.86</td>
<td>95.98 ±7.37</td>
</tr>
</tbody>
</table>

Table 4.16 Mean and standard deviation for average Self-Efficacy at pre-test and 5-, 15-, and 30-min post test

**Sample T-Test**
The one sample t-test showed that the increase in self-efficacy from pre-test to 5 min post test was significant for both the moderate \((t=.38, p=.001)\) and the high intensity \((t=4.67, p=.000)\) exercise sessions.

**Paired T-test**

The paired t-test showed that there was no statistical difference for self-efficacy change from pre-test to 5 min post test between the moderate and the high intensity \((t=-1.491, p=.153)\) sessions. After both the moderate and the high intensity exercise, self-efficacy scores were not significantly different from 5 min to 15 min post test and from 15 min to 30 min post test. Paired t-test showed that the average self-efficacy at pre-test for the moderate intensity was significantly higher than the average self-efficacy at pre-test for the high intensity \((t=5.52, p=.00)\).
Exercise has been shown to be an effective, simple and inexpensive approach to reduce and alleviate symptoms of depression and it might be an important tool for public health improvement (Martinsen, 2000). Adherence to regular exercise is a problem, and may be more of a challenge for those suffering from major depression. In light of these barriers, it is important to understand how people respond to exercise and how the affect changes at various stages of the exposure to the exercise stimulus. Researchers want to determine the mode, intensity and frequency of exercise sessions that are associated with the most health benefits and in particular the psychological responses (mood, feeling states). The Opponent Process Theory provides us with a framework for studying the benefits of exercise over a relevant period of time (from before the exercise session starts until all the psychological benefits are exhausted). Mechanisms and theories are very important at this stage, when the correlation between exercise and improved mental health is not debated but not completely explained either.

The primary purpose of this study was to test the Opponent Process Theory (OPT)’s application to exercise by determining whether a high intensity exercise bout is associated with a higher magnitude of post-exercise pleasure than a moderate intensity exercise bout. Participants were sedentary women with symptoms of depression.
The response to an exercise session can be divided into two distinct and disjoint phases: the response during exercise and the response after exercise. These two segments correspond to the a- and b- processes theorized by the Opponent Process Theory (Solomon, 1980). This theory hypothesizes that the organism’s response to a stimulus comes in two phases: during the time when the stimulus is present and after the time the stimulus ends. Also, the two separate responses are opposite (one is positive and one is negative) and of various magnitudes.

Using the OPT in the context of exercise as a stimulus is often difficult, as one needs to measure affective responses at multiple points in time, from pre-exercise, during and post exercise. The pattern of change is dynamic and multiple measurements are needed within each phase (a and b) in order to capture the continuous effect of the stimulus. In a recent study Lochbaum et al., (2004) mentioned that although several researchers had cited Solomon's work as potential support for their results, they found no studies that included measurement time points during exercise.

This study extended the research that has tested the OPT with exercise by measuring affect responses three times during exercise using the Self-Assessment Mannequin (SAM) pictorial questionnaires. Three affective dimensions were captured in respect to type (i.e., pleasure, arousal, dominance) and magnitude. Responses were also recorded at four time points after acute exercise, the final occurring 30 min after the session was over. It was hypothesized that pleasure responses during and after a higher
intensity session would be greater compared to those during and after a moderate intensity session.

During the moderate intensity session (a-process), the drop in pleasure was significant from pre-test to the last measurement during exercise while for the high intensity session, the drop in pleasure was significant from pre-test to all measurements during exercise. We also determined that the drop in pleasure during exercise was significantly greater for high intensity compared with moderate intensity (from pre-test to all measurement points during exercise). The change scores between consecutive measurements during exercise were not significant between the two intensities. The results are in support of a “shock” effect from higher intensity exercise, manifest as a significant and early (i.e., within first 5-min of exercise) loss of pleasure, which levels off with no other significant changes recorded during exercise. The drop during the first five min drives the difference between the two different intensities of exercise.

After exercise, pleasure scores experienced a rapid shift upwards, corresponding to the b-process of the OPT. For the moderate session, the increase in score is significant from the new baseline (end of session) to 5 and 15 min post exercise. For the high intensity, all changes in pleasure are significant (from baseline to all measurement points post-exercise and between consecutive measurements post exercise). Moreover, the high intensity is associated with significantly higher increase in pleasure compared to moderate intensity exercise for all time segments during the b-process.
Although limited to two intensity conditions, the results are consistent with a
dose-response effect, higher intensities being required for significant pre-post effects.
This result is in line with the findings by Singh and his colleagues (2005) who found that
only the high intensity exercise condition was associated with significant clinical benefits
in a depressed population.

The increase in pleasure after the high intensity exercise bout is consistent with
previous research (Hall, 2002; Ekkekakis & Petruzzello, 1999) that showed an
instantaneous rebound from affective negativity to affective positivity as soon as the
strenuous exercise had ended. Hall (2002) defined affect using a two-dimensional model
(Pleasure X Activation), and measured it repeatedly before, during and after the exercise
on a sample of 30 healthy university students. He found that after a vigorous intensity
bout, affective valence increased instantaneously during cool-down. Ekkekakis &
Petruzzello (1999) reviewed 31 studies and found consistent patterns of increased
positive affect post vigorous exercise bouts.

The increase in pleasure from pre-test to 5-min post-exercise was not different
between intensity conditions, but 15 and 30 min post exercise were significantly greater
for the high intensity compared to the moderate intensity conditions. Thus, the difference
between the high and moderate intensity effect on pleasure was delayed. The concept of
delay of the effect has been referenced before in many contexts (Raglin, 1993, Cox, 2000,
2004). Cox (2000) found a delayed anxiolytic effect following an acute bout of 30 min of
exercise on an assigned apparatus (jogging or stepping) at an intensity of either 50% or 75% of VO$_{2\text{max}}$.

In a sense, the delay in effect observed post-exercise is the opposite of the “shock” experienced during the first 5 min of the bout. The delay represents the time it takes the affect to recover from the a-process effect and to increase above the baseline.

The main effect of intensity and the superiority of the high intensity in terms of elevating pleasure are in accordance with the results from the study by Cox and his colleagues (2006), in which they found that high intensity exercise is associated with a higher elevation of positive affect post exercise, compared to the moderate intensity exercise. The results are inconsistent, however, with a study by Tuson, Sinyor and Pelletier (1995), who found no significant difference between high and moderate exercise intensities in affective responses.

After the moderate intensity bout, the increase in pleasure from pre-test to post-test (5, 15 and 30 min) was not significant. After the high intensity bout, the increase in pleasure was significant from pre-test to all post-test measurement points (5, 15 and 30 min). These findings are consistent with the results from the study by Cox and his colleagues (2006), who found significant changes for positive well-being for high intensity exercise between baseline and 5 and 30 min post-exercise. Consistent with OPT, the b-process has a slower decay than the a-process (Solomon, 1980). In the case of the high intensity, the decay did not start within the first 30 min post exercise. Even though
not significant, the mean score for the moderate intensity is also above the mean score pre-test. Consistent with Hall and his colleagues (2002) who equates the positive affective changes after vigorous activity with the cessation of the bout rather than the bout itself, we believe that the increase in pleasure after exercise reflects the fact that the bout has ended rather than the activity was enjoyable. Moreover, the design of SAM determinants reflects the current state of affect rather than a retrospective measure of affect during the bout. As a partial support of this hypothesis, it is interesting to notice that the variable (e.g., enjoyment) that reflects the retrospective view of the exercise bout showed no significant difference between the two exercise intensities, while the SAM pleasure/happiness patterns were significantly different.

Not unexpectedly, the pattern of mean scores for arousal was reversed, as arousal increased during exercise and decreased once the exercise session ended for both moderate and high intensity. During the moderate intensity exercise, arousal increased significantly from pre-test to all measurement points during exercise. For the high intensity, the increase in arousal was significant from pre-test to all measurement points during exercise and also between consecutive measurement points during exercise.

The higher intensity is associated with a significantly higher increase in arousal from pre-test to the second measurement during exercise and to the third measurement during exercise. The difference in effects for consecutive measurements during exercise
is also significant, from the first to the second and from the second to the third measurement during exercise.

The difference between the high intensity and the moderate intensity is not significant between pre-test and the first measurement during exercise (at 5 min). Unlike the pattern for pleasure, where the first five min drove the differences between high and moderate bouts, the change score from 5 min to the middle of the session and from the middle of the exercise bout to 5 min before the end drove the difference in arousal between the moderate and the high intensity.

After the moderate intensity bout, arousal decreases significantly from the end of exercise session to 5, 15 and 30 min post exercise. The decrease in arousal for the high intensity did not reach significance until 15 and 30 min post exercise. Moreover, the high intensity is associated with a significantly greater drop in arousal from time baseline to time 15 and 30 min post exercise. The high intensity is associated with higher arousal across all the measurement points (for both a and b process) but the change from pre-test to 30 min post-exercise is not statistically different between the two exercise conditions (moderate and high).

Arousal patterns are not in accord with the OPT. Opponent Process Theory predicts that higher intensity stimulus will be associated with a more powerful response for both a and b process. While during exercise this pattern is followed (significantly
higher increase in arousal for the high intensity exercise), the magnitude of the drop in arousal after exercise is not dominated by the high intensity.

The three dimensional design of the SAM can accurately describe any emotion, with anxiety being defined as the intersection of high arousal and low pleasure scales. OPT’s a-process drives pleasure down and arousal up, and hence participants’ affect is directed towards a state of anxiety. This is in accord with the results by Raglin and Wilson (1996) who found that anxiety was elevated at 5 min post exercise following the bout at high intensity (70% of VO\textsubscript{2peak}) but not at subsequent measurement (60 and 120 min) post exercise. In our study, after the 5 min mark post exercise, arousal continued to drop and pleasure continued to increases, consequently driving anxiety down (see Appendix L). Also, arousal was significantly lower following the moderate intensity compared to the high intensity session, and this is in line with the results from the study by Raglin and Wilson (1996), who determined that following the moderate intensity bouts (40% of VO\textsubscript{2peak}), anxiety was reduced at all measurement points (including at 5 min post test).

Along the same lines, Cox, Thomas and Davis (2000) found similar results but unlike the previous study, the effect of the moderate intensity on anxiety was delayed (after 5 min) for the moderate intensity. A reconciliation of these results could be the possible hypothesis that the 5 min mark post exercise is the point in time where the interaction between pleasure and arousal drives anxiety below the baseline value.
Dominance patterns differ between the two intensities. For the moderate intensity, the mean dominance scores increase over time, while for the high intensity, the mean scores decrease during exercise and then recover after the exercise session ends. Perceptions of dominance were consistent during the moderate intensity session. There was no significant change between any time segments during exercise for the moderate intensity. For the high intensity, the decrease in dominance was significant from time pre-test to all measurement points during exercise. Also, the high intensity is associated with a significantly greater drop in dominance from pre-test to all measurement points during exercise. The increase in dominance after both sessions was significant from the end of the bout to 5, 15 and 30 min post exercise. For the high intensity the increase in dominance was also significant from 15 to 30 min post exercise. Finally, the high intensity is associated with a significantly higher increase in dominance from the end of the bout to 30 min post exercise. The differences between the effects of the two intensities for dominance from time 0 to time 7 are not significant.

Dominance patterns are counterintuitive at first, when analyzed in the context of OPT. Dominance increased during and after the moderate intensity bout. One possible explanation for this result is the fact that the stimulus associated with the moderate intensity is not powerful enough to unleash the effect predicted by OPT. It is possible that the moderate intensity is below a necessary threshold in order to start the a-process. From a psychological perspective, the moderate intensity allowed the participants to be very
confident that they could finish the bout and their dominance increased even during exercise.

The mean RPE scores were 10.5 during the moderate intensity bout and 15.2 during the high intensity bout. According to the verbal anchors for the Borg 6-20 scale, 10.5 is between very light and light, while 15.2 corresponds to hard. Therefore, the participants perceived the moderate bout as a lighter intensity than what we expected through our design. This lower perceived intensity for the moderate bout together with an intensity threshold required for OPT processes could explain some of the results for the moderate intensity. According to Solomon (1980), there is a need for a critical intensity of the a-process in order for the opponent process (b-process) to be started.

For the high intensity, dominance dropped within the first five min during exercise substantially, but the drop after this point is not statistically significant, so we can theorize a leveling off of the effect, as participants got accustomed to the intensity. After exercise, dominance increased significantly during each time segment, except the last 15 min post exercise.

The secondary purpose of the study was to determine whether participants would pick the intensity that corresponded to higher and longer lasting positive affect after exercise. The hypothesis was partially rejected, as the intensity of choice was not the one with the greater increase in pleasure (SAM). However, 14 of 18 participants (77.8%) selected the intensity associated with the higher enjoyment score at 15 and 30 min, but
not at 5 min post exercise. A possible explanation for these results is the fact that SAM records current state of affect while the measure for exercise enjoyment (PAES) is a retrospective measure of affect during exercise. The participants’ choice was the intensity associated with the highest enjoyment during exercise, as recalled at 15 and 30 min post exercise. It is interesting to mention that exercise enjoyment, as recalled at 5 min after exercise was not the same as the enjoyment recalled at 15 and 30 min post test. The mismatch in timing (current state vs. retrospective) could explain the differences. Moreover, the participants made the choice of intensity when they came to the laboratory for the last session, while our assessments of affect related to the exercise sessions were taken no longer than 30 min after the two earlier exercise sessions were over. This is a seed for another mismatch, as participants likely made their intensity selection based on a more comprehensive picture of affect changes than the limited information that was included in our design.

The average self-efficacy at pre-test for the moderate intensity was significantly higher than the average self-efficacy at pre-test for the high intensity. The increase in self-efficacy from pre-test to 5 min post test was significant for both the moderate and the high intensity exercise sessions and there was no statistical difference for self-efficacy change from pre-test to 5 min post test between the moderate and the high intensity sessions. After both intensity bouts, self-efficacy scores were not significantly different from 5 min to 15 min post test and from 15 min to 30 min post test.
Self-efficacy for exercise refers to a very important psychological mechanism that is based on perceptions of effort and the confidence of individuals in completing a task. Both pleasure and self-efficacy increased post exercise, consistent with Bandura’s hypothesis (1986) of a reciprocal relationship between self-efficacy and affect. In the absence of a clear, indubitable mechanism for the effect of exercise in reducing depressive symptoms, it is important to study variables that are correlated or predictive of depression and the methods to change them in the positive direction.

Exercise has different effects on different people. Studying the effect on mood for healthy individuals could give different results than studying the same effects for depressed people. Moreover, psychological benefits are needed by people with mental health problems more than healthy individuals. This is why it is important to study the psychological benefits of exercise on depressed people, because they are the ones that need the help. The framework given by Opponent Process Theory allows us to study and better understand one of the most important parameters of exercise prescriptions, intensity. Most psychological benefits of exercise are obtained after the bout has ended and the process that drives this effect is the OPT’s b-process. For this process to take place, a-process (during exercise) needs to be stimulated by an intensity above a certain threshold. It is this threshold that is at the base of the understanding of the most beneficial exercise prescription. Depressed individuals benefit from increased well-being post
exercise, and hence in order to better treat them, we need to understand what intensity
triggers these benefits and also improves adherence to exercise programs.

The decrease in pleasure during the exercise session which underlies the a-process is consistent with the fact that the participants in the study were sedentary. One
dimension of OPT (Solomon, 1980) says that people with consistent exposure to the
stimulus respond differently than people that are exposed to it infrequently. In our case,
fit individuals would show little a-process effect and greater b-process effect. Sedentary
individuals, on the other hand, exhibit powerful a-process effect, characterized by
negative affect. Studying the dynamic nature of the negative effect during exercise and
the positive effect post exercise allows us to better understand, predict and prescribe
exercise for depressed, sedentary people.

Limitations of the study and future research

Spending 30 min in a laboratory setting following exercise may have affected the
participants’ responses. The number of questionnaires that the participants were asked to
complete might have been a burden that affected their responses. Also, in order to try and
capture the affect during exercise, we used SAM. This instrument has not been used in
previous studies of acute exercise and thus we were unable to compare these findings
with other literature. We used The Beck Depression Inventory (BDI) to identify
depressed individuals. This is commonly used to identify depressed individuals, but
according to Martinsen (2001) it is not a satisfactory instrument, as formal diagnoses are not made. Another limitation of the study might be fact that the exercise sessions were made in a controlled environment, hence the limited ecological validity of the study.

It is recommended that future research recruit a larger sample and it might be useful to conduct a study on clinically depressed participants.

Another research question could go deeper into the mechanism that is used by individuals to pick the intensity of their choice. Is it based on what they feel during exercise (a-process) or post exercise (b-process)? Can the intensity of choice be predicted by the magnitude of the positive (or negative) effects experienced during (post) exercise?

Another future research idea could extend the timeline for post exercise measurements beyond 30 min to better capture the dynamic nature of affect changes. Other studies (e.g., Wilson & Raglin, 1996) measured affect as long at 120 min post exercise.

In conclusion, the primary purpose to test the OPT was supported. Higher intensity exercise bouts were associated with higher magnitude (both negative, during a-process and positive, during b-process) and longer lasting response (pleasure) post exercise compared to a bout of moderate intensity exercise. This result is important in the context of exercise prescriptions as higher intensities (above a certain threshold) are associated with significantly greater changes in positive affect post exercise. Finally, the secondary purpose was partially supported, as depressed women selected intensities
associated with exercise enjoyment recalled post exercise. This was more important than the experiencing a great increase in pleasure post exercise.
APPENDIX A

FLYER
Depression Research Study

Did you know that ..........

- Physical activity can reduce the severity of symptoms in depressed patients
- Exercise therapy is four to five times more cost-effective than traditional treatments for depression

Volunteer Participants Needed!!

If you are

- Woman
- Age 18-50
- Not pregnant or nursing
- Not obese
- Not currently enrolled in an exercise program

If you have either a current diagnosis of depression or feel that you are coping with mild to moderate depressive symptoms, you can participate in an OSU study on the benefits of exercise in helping to alleviate depressive symptoms.

For further information, contact Maria Rozorea at (614) 264-4503 or rozorea.1@osu.edu
Cunz Hall, Room 354
1841 Millikin Road
Columbus, OH, 43210

This research study will take place on the campus of THE OHIO STATE UNIVERSITY
APPENDIX B

BECK DEPRESSION INVENTORY
Name: ___________________________ Marital Status: ___________________ Age: ________ Sex: ________
Occupation: ____________________ Education: _________________________

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the one statement in each group that best describes the way you have been feeling during the past two weeks, including today. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. Sadness
   0 I do not feel sad.
   1 I feel sad much of the time.
   2 I am sad all the time.
   3 I am so sad or unhappy that I can’t stand it.

2. Pessimism
   0 I am not discouraged about my future.
   1 I feel more discouraged about my future than I used to be.
   2 I do not expect things to work out for me.
   3 I feel my future is hopeless and will only get worse.

3. Past Failure
   0 I do not feel like a failure.
   1 I have failed more than I should have.
   2 As I look back, I see a lot of failures.
   3 I feel I am a total failure as a person.

4. Loss of Pleasure
   0 I get as much pleasure as I ever did from the things I enjoy.
   1 I don’t enjoy things as much as I used to.
   2 I get very little pleasure from the things I used to enjoy.
   3 I can’t get any pleasure from the things I used to enjoy.

5. Guilty Feelings
   0 I don’t feel particularly guilty.
   1 I feel guilty over many things I have done or should have done.
   2 I feel quite guilty most of the time.
   3 I feel guilty all of the time.

6. Punishment Feelings
   0 I don’t feel I am being punished.
   1 I feel I may be punished.
   2 I expect to be punished.
   3 I feel I am being punished.

7. Self-Dislike
   0 I feel the same about myself as ever.
   1 I have lost confidence in myself.
   2 I am disappointed in myself.
   3 I dislike myself.

8. Self-Criticalness
   0 I don’t criticize or blame myself more than usual.
   1 I am more critical of myself than I used to be.
   2 I criticize myself for all of my faults.
   3 I blame myself for everything bad that happens.

9. Suicidal Thoughts or Wishes
   0 I don’t have any thoughts of killing myself.
   1 I have thoughts of killing myself, but I would not carry them out.
   2 I would like to kill myself.
   3 I would kill myself if I had the chance.

10. Crying
    0 I don’t cry anymore than I used to.
    1 I cry more than I used to.
    2 I cry over every little thing.
    3 I feel like crying, but I can’t.

Subtotal Page 1  Continued on Back
11. Agitation
0  I am no more restless or wound up than usual.
1  I feel more restless or wound up than usual.
2  I am so restless or agitated that it’s hard to stay still.
3  I am so restless or agitated that I have to keep moving or doing something.

12. Loss of Interest
0  I have not lost interest in other people or activities.
1  I am less interested in other people or things than before.
2  I have lost most of my interest in other people or things.
3  It’s hard to get interested in anything.

13. Indecisiveness
0  I make decisions about as well as ever.
1  I find it more difficult to make decisions than usual.
2  I have much greater difficulty in making decisions than I used to.
3  I have trouble making any decisions.

14. Worthlessness
0  I do not feel I am worthless.
1  I don’t consider myself as worthwhile and useful as I used to.
2  I feel more worthless as compared to other people.
3  I feel utterly worthless.

15. Loss of Energy
0  I have as much energy as ever.
1  I have less energy than I used to have.
2  I don’t have enough energy to do very much.
3  I don’t have enough energy to do anything.

16. Changes in Sleeping Pattern
0  I have not experienced any change in my sleeping pattern.
1a  I sleep somewhat more than usual.
1b  I sleep somewhat less than usual.
2a  I sleep a lot more than usual.
2b  I sleep a lot less than usual.
3a  I sleep most of the day.
3b  I wake up 1–2 hours early and can’t get back to sleep.

17. Irritability
0  I am no more irritable than usual.
1  I am more irritable than usual.
2  I am much more irritable than usual.
3  I am irritable all the time.

18. Changes in Appetite
0  I have not experienced any change in my appetite.
1a  My appetite is somewhat less than usual.
1b  My appetite is somewhat greater than usual.
2a  My appetite is much less than before.
2b  My appetite is much greater than usual.
3a  I have no appetite at all.
3b  I crave food all the time.

19. Concentration Difficulty
0  I can concentrate as well as ever.
1  I can’t concentrate as well as usual.
2  It’s hard to keep my mind on anything for very long.
3  I find I can’t concentrate on anything.

20. Tiredness or Fatigue
0  I am no more tired or fatigued than usual.
1  I get more tired or fatigued more easily than usual.
2  I am too tired or fatigued to do a lot of the things I used to do.
3  I am too tired or fatigued to do most of the things I used to do.

21. Loss of Interest in Sex
0  I have not noticed any recent change in my interest in sex.
1  I am less interested in sex than I used to be.
2  I am much less interested in sex now.
3  I have lost interest in sex completely.

NOTICE: This form is printed with both blue and black ink. If your copy does not appear this way, it has been photocopied in violation of copyright laws.
APPENDIX C

DEMOGRAPHIC DATA SHEET
Background Information

Name:
The following statements ask you to identify some basic information about yourself. Please fill in the blank or check the appropriate boxes.

1. Age: _____

2. Address: _______________________________________________________

Phone: _______________________ Email: _________________________

3. How would you describe yourself? 
   White - not Hispanic  Black - not Hispanic  Hispanic
   Asian of Pacific Islander  American Indian or Alaskan Native
   Other

4. With whom do you currently live? (Select all that apply.)
   Alone   Spouse/domestic partner   Roommate(s)/friend(s)
   Parent(s)/guardian(s)
   Other relatives   Your children   Other

5. Do you work?   YES  NO
   If YES, part-time   full-time   (Total hours worked per week)

6. Are you a student? If YES, what academic class?
   Freshman   Sophomore   Junior   Senior
   5th Year or more   Graduate   Other
   If YES, course load:
   Full-time (12 credit hours)   Part-time (<12 credit hours)

7. Have you used the following tobacco products? Please CHECK all that apply.
   Cigarettes?   Age started_______ Age quit_______ No. per day
   Cigars/Pipes?   Age started_______ Age quit_______ No. per day
Snuff/dip/chew?  Age started_______  Age quit_________  No. per day

8. A. Do you have any reason to suspect that you are pregnant?

YES  NO
If YES, explain why ________________________________

B. Please, state the first day of your menstrual cycle ________________

9. Have any of your blood relatives (that is, mother, father, siblings, grandmother, grandfather) had any of the following? (Check & indicate relationship)

<table>
<thead>
<tr>
<th>Relative(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease</td>
</tr>
<tr>
<td>High blood pressure</td>
</tr>
<tr>
<td>Elevated cholesterol</td>
</tr>
<tr>
<td>Diabetes</td>
</tr>
<tr>
<td>Obesity</td>
</tr>
<tr>
<td>Depression</td>
</tr>
</tbody>
</table>

10. Date of last medical exam:_______________ Were results normal?

YES  NO
If no, please explain:

11. List any medications or drugs you are now taking:

<table>
<thead>
<tr>
<th>Medication name</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pill size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pill dose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Times/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For how long?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. Do you know of any medical problems that might make it dangerous or unwise for you to participate in vigorous exercise?

YES  NO  If YES, please explain

Thank you
CLEARANCE OF PERSONAL PHYSICIAN

1. ___________________________________________ is interested in a maximal graded exercise test with oxygen consumption measurements. All testing policy and procedures follow the recommendations of the American College of Sports Medicine.

2. Please indicate the suitability of your patient to participate in the evaluation.

   ______ I know of no reason why he/she may not be tested.

   ______ I feel he/she may be evaluated, but urge caution due to:

   __________________________________________________________________________

   __________________________________________________________________________

   __________________________________________________________________________

   __________________________________________________________________________

   ______ This patient's present history contraindicates this fitness evaluation.

_______________________________________________________________________________

Physician's signature                     Date

_______________________________________________________________________________

(type or print name)

131
APPENDIX E

EXERCISE STAGE OF CHANGE
Exercise Stage of Change

Exercise includes activities such as brisk walking, jogging, swimming, aerobic dancing, biking, rowing, weight lifting, etc. Activities that are primarily sedentary such as bowling, or playing golf with a cart, would not be considered exercise.

Do you exercise regularly, that is, 3 or more times each week for at least 20 minutes each time?

(Please check one statement below that best describes you.)

☐ Yes, I have been for more than 6 months.
☐ Yes, I have been for less than 6 months.
☐ No, but I am planning to start in the next 30 days.
☐ No, but I am planning to start in the next 6 months.
☐ No, and I don't have plans to start in the next 6 months.
APPENDIX F

GODIN LEISURE-TIME EXERCISE QUESTIONNAIRE
Godin Leisure-Time Exercise Questionnaire

Considering a 7-day period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time. Write on each line the appropriate number.

a) STRENUOUS EXERCISE (HEART BEATS RAPIDLY) __________________
   (for example, running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, roller skating or blading, vigorous swimming, vigorous long-distance biking)

b) MODERATE EXERCISE (NOT EXHAUSTING) __________________
   (for example, fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, down-hill skiing, popular and folk dancing)

C) MILD EXERCISE (MINIMAL EFFORT) __________________
   (for example, yoga, archery, fishing from river bend, bowling, horseshoes, golf, snow-mobiling, easy walking)

Considering a 7-day period (a week), during your leisure-time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?

          OFTEN          SOMETIMES          NEVER / RARELY
              ________  ________  ________

APPENDIX G

RATINGS OF PERCEIVED EXERTION SCALE
6 No exertion at all
7 Extremely light
8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion
APPENDIX H

SELF-ASSESSMENT MANIKIN (SAM)
APPENDIX I

PHYSICAL ACTIVITY ENJOYMENT SCALE
At the moment, how do you feel about the physical activity you have been doing? Some feelings about physical activity are listed below. Please circle the number that describes your current feelings about physical activity for each pair of feelings.

<table>
<thead>
<tr>
<th>Pleasurable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Not Pleasurable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like it</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Dislike it</td>
</tr>
<tr>
<td>Fun</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Not fun</td>
</tr>
<tr>
<td>Absorbed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Not absorbed</td>
</tr>
<tr>
<td>Bored</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Interesting</td>
</tr>
<tr>
<td>Energizing</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Tiring</td>
</tr>
<tr>
<td>Depressed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Happy</td>
</tr>
<tr>
<td>Pleasant</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Unpleasant</td>
</tr>
<tr>
<td>Invigorating</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Not Invigorating</td>
</tr>
<tr>
<td>Frustrated</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Not Frustrated</td>
</tr>
<tr>
<td>Gratifying</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Not Gratifying</td>
</tr>
<tr>
<td>Sense of Accomp</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>No sense of Accomp</td>
</tr>
</tbody>
</table>
APPENDIX J

SELF-EFFICACY SCALE
The items listed below are designed to assess your beliefs in your ability to walk at a moderate pace without stopping. Using the scale listed below, please indicate how confident you are to complete the amount of walking listed in the question.

For example, in question #1, if you have complete confidence that you can walk 5 minutes at a moderate pace without stopping you would circle 100%. However, if you had no confidence at all that you can walk 5 minutes at a moderate pace without stopping you would circle 0%.

Please remember to answer honestly and accurately. There are no right or wrong answers.

Mark your answer by circling a %:

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NOT AT ALL MODERATELY COMPLETELY
CONFIDENT CONFIDENT CONFIDENT

Please circle the number below that indicates how confident you are that you can walk at a moderate pace (40% of your VO2max) without stopping.

1. I can walk for 5 minutes at a moderate pace (40% of my VO2max) without stopping.
2. I can walk for 10 minutes at a moderate pace (40% of my VO2max) without stopping.
3. I can walk for 15 minutes at a moderate pace (40% of my VO2max) without stopping.
4. I can walk for 20 minutes at a moderate pace (40% of my VO2max) without stopping.
5. I can walk for 25 minutes at a moderate pace (40% of my VO2max) without stopping.

143
The items listed below are designed to assess your beliefs in your ability to walk at a moderately vigorous to vigorous pace without stopping. Using the scale listed below, please indicate how confident you are to complete the amount of walking listed in the question.

For example, in question #1, if you have complete confidence that you can walk 5 minutes at a moderately vigorous to vigorous pace without stopping you would circle 100%. However, if you had no confidence at all that you can walk 5 minutes at a moderately vigorous to vigorous pace without stopping you would circle 0%.

Please remember to answer honestly and accurately. There are no right or wrong answers.

Mark your answer by circling a %:

<table>
<thead>
<tr>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT AT ALL</td>
<td>MODERATELY</td>
<td>COMPLETELY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONFIDENT</td>
<td>CONFIDENT</td>
<td>CONFIDENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please circle the number below that indicates how confident you are that you can walk at a moderately vigorous to vigorous pace (70% of your VO$_{2\text{max}}$) without stopping.

1. I can walk for 5 minutes at a moderately vigorous to vigorous pace (70% of my VO$_{2\text{max}}$) without stopping.

2. I can walk for 10 minutes at a moderately vigorous to vigorous pace (70% of my VO$_{2\text{max}}$) without stopping.

3. I can walk for 15 minutes at a moderately vigorous to vigorous pace (70% of my VO$_{2\text{max}}$) without stopping.

4. I can walk for 20 minutes at a moderately vigorous to vigorous pace (70% of my VO$_{2\text{max}}$) without stopping.
APPENDIX K

DATA COLLECTION SHEET
Subject #  Height:
Name:  Weight:

Visit 1 – Bruce Protocol VO2max

<table>
<thead>
<tr>
<th>Rest HR =</th>
<th>Rest RPE =</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7 - 10%</td>
<td>0 – 3 minutes</td>
</tr>
<tr>
<td>2.5 - 12%</td>
<td>3-6 minutes</td>
</tr>
<tr>
<td>3.4 - 14%</td>
<td>6-9 minutes</td>
</tr>
<tr>
<td>4.2 - 16%</td>
<td>9-12 minutes</td>
</tr>
<tr>
<td>5.0 - 18%</td>
<td>12-15 minutes</td>
</tr>
</tbody>
</table>

END TIME =

Visit 2 – 150 calories at 40% VO2 max. Time on the treadmill: minutes
SPEED =
GRADE =

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-test</th>
<th>During</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAM Subscales</td>
<td>Just before test</td>
<td>End of 5 min</td>
<td>Middle</td>
</tr>
<tr>
<td>Pleasure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAES</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RPE

Minute
Score
**Visit 3 – 150 calories at 70% VO2 max. Time on the treadmill: minutes**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-test</th>
<th>During</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAM subscales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Just before test</td>
<td>End of 5 min</td>
<td>Middle</td>
</tr>
<tr>
<td>Pleasure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAES</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Visit 4 – 150 calories at self-selected intensity (40% or 70% VO2 max)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-test</th>
<th>During</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAM subscales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Just before test</td>
<td>End of 5 min</td>
<td>Middle</td>
</tr>
<tr>
<td>Pleasure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAES</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**RPE**

<table>
<thead>
<tr>
<th>Minute</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Visit 3 – 150 calories at 70% VO2 max. Time on the treadmill: minutes**

**SPEED =**

**GRADE =**

**Visit 4 – 150 calories at self-selected intensity (40% or 70% VO2 max)**

**SPEED =**

**GRADE =**

**Visit 3 – 150 calories at 70% VO2 max. Time on the treadmill: minutes**

**SPEED =**

**GRADE =**

**Visit 4 – 150 calories at self-selected intensity (40% or 70% VO2 max)**

**SPEED =**

**GRADE =**
APPENDIX L

PLEASURE/AROUSAL EFFECT FROM PRE-TEST TO 30 MIN POST-TEST
Figure 5.1 Pleasure and arousal at four measurement points: pre, during (middle of the session), end, and 30 min post test
REFERENCES


Green, R.M. (1951) *A Translation of Galen’s Hygiene (de Sanitate Tuenda)*. Charles C Thomas Publisher, Springfield, IL.


Institute of Medicine (2002). Board of Neuroscience and Behavioral Health, National Academies of Press, Washington DC.


