1995

The Psychological Effects of Functional Electrical Stimulation Leg Cycle Ergometry on Persons with Spinal Cord Injury

Renee Christner
Grand Valley State University

Scott Nolte
Grand Valley State University

THE PSYCHOLOGICAL EFFECTS OF FUNCTIONAL ELECTRICAL STIMULATION LEG CYCLE ERGOMETRY ON PERSONS WITH SPINAL CORD INJURY

By

Renee Christner
Scott Nolte

THESIS

Submitted to the Department of Physical Therapy
at Grand Valley State University
Allendale, Michigan
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE IN PHYSICAL THERAPY

1995

ABSTRACT

Major depressive disorder (MDD) affects many individuals in the general population. Spinal cord injury (SCI) may exacerbate depressive symptoms as individuals must adapt to an altered lifestyle as a result of the injury. The purpose of this study was to investigate the effects of Functional Electrical Stimulation Leg Cycle Ergometry (FES-LCE) on the subjective reports of the incidence and severity of symptoms of depression in individuals with SCI. Survey packets, including a demographic data sheet and the Inventory to Diagnose Depression (IDD), were mailed to 215 individuals participating in FES-LCE programs and 215 persons with SCI not involved in FES-LCE. One hundred forty-one returned questionnaires were analyzed. Seven percent of those individuals not participating in FES-LCE were diagnosed with MDD and 13% were classified in the Mild-Severe depressive symptom category by the IDD. Conversely, no subjects who participated in a FES-LCE program were diagnosed as having MDD or were grouped in the Mild-Severe depressive symptom category by the IDD. The results of this study indicate that more people with SCI could be benefiting from FES-LCE.

ACKNOWLEDGMENTS

The researchers would like to extend their appreciation to the many individuals whose assistance made completion of this project possible. First, thank you is extended to Barb Baker, committee chair, Jim Scott, Brian Curry and Karen Ozga, committee members, for their invaluable assistance and continued guidance in completion of this project. Special thanks are extended to Dr. Mark Zimmerman and Dr. Jim Blakey for their assistance in obtaining the Inventory to Diagnose Depression and guidance in the administration of the IDD. The researchers would also like to thank Cindy Zehner for her "behind the scenes" assistance with all of the mailings; the Grand Valley State University Department of Physical Therapy for supplying envelopes and letter head for the survey packets; Dianne McIntosh for her mentorship and assistance in locating subjects; Steve Bushouse for his input on the design of the demographic data sheet; Gerry Hakala for his help with the mailings; Lyman Phillips at the NSCIA for his assistance in locating subjects and Evelyn Marks at Rancho Los Amigos library for her assistance with our literature review. Finally, thanks are also extended to the families of the researchers for their patience and understanding during the completion of this project.

PREFACE
Glossary of Terms

Control Group - Individuals with SCI not involved in any form of regular exercise

Experimental Group - Individuals with SCI currently involved in regular FES-LCE exercise 2-3 x's/week for at least 30 minutes/ session for at least 6 months.

Functional Electrical Stimulation-Leg Cycle Ergometry (FES-LCE) - Sequential stimulation of motor-endpoints of the quadriceps, gluteal and hamstring muscles using low levels of monophasic wave pulses which causes paralyzed leg muscles to drive the cranks of an ergometer.

Major Depressive Disorder (MDD) - One or more major depressive episodes without a history of either a manic episode or an unequivocal hypomanic episode.

Physical Activity - FES-LCE program participation or participation in other forms of exercise such as arm ergometry, walking or standing in a standing frame.

Questionnaire - Includes the demographic data sheet and the Inventory to Diagnose Depression.

Reactive Depression - A normal bereavement process in response to significant separations and losses with anxiety symptoms such as initial insomnia, restlessness and hyperactivity.

Regular exercise - Exercising with a frequency of 2-3 x's/wk, for at least 30 minutes/session for at least 6 months

Survey Packet - Includes the demographic data sheet, Inventory to Diagnose Depression, a cover letter, results request postcard and return envelope.

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CHAPTER 1: INTRODUCTION

Over 500,000 people in the United States have become disabled as a result of spinal cord injury (SCI). Slightly over one half of these individuals experience tetraplegia. This year alone, over 7,800 persons are estimated to sustain and survive a traumatic SCI. Unfortunately, there will be another 4,860 people who will die from SCI this year (National Spinal Cord Injury Association Statistical Center Fact Sheets 1 & 2, 1992). Estimates of intoxication at the time of injury for persons with SCI vary from 40 to 62% (Fullerton, Harvey, Klein & Howell, 1981; O'Donnell, Cooper, Gessner, Shehan & Ashley, 1981; Tate, 1993). The vast majority of SCI's are caused by motor vehicle accidents (MVA's) (45%), followed by falls (22%), acts of violence (16%), sports (13%) and other causes (4%). Eighty-two percent of those with SCI are male, with the highest per capita rate of injury occurring between the ages of 16-30 (National Spinal Cord Injury Association Statistical Center Fact Sheets 1 & 2, 1992).

SCI occurs when there is enough force exerted on the spinal cord to interrupt some (an "incomplete" injury) or all (a "complete" injury) of the neural pathways contained within the spinal cord at a specific level. Further neurologic deficits result from the enormous amount of edema caused by the injury. This edema alone can destroy up to 70% of the spinal cord within just 24 hours after the injury (Buchanan & Nawoczenski, 1987). As a result, the function of all spinal segments below the level of the lesion is impaired. The degree of loss of function is determined by the level at which the injury occurs because each level of the spinal cord innervates specific myotomes and dermatomes. Therefore, the higher the level of the lesion, the greater the loss of function. Tetraplegia, formerly referred to as quadriplegia, literally means "paralysis affecting all four limbs" (American Spinal Cord Injury Association, 1992; The Bantam Medical Dictionary, 1990). It refers to impairment or loss of motor and/or sensory function due

to damage of the cervical segments in the spinal cord. Tetraplegia results in impairment of function in the arms, trunk, legs and pelvic organs. (American Spinal Cord Injury Association, 1992). It includes injuries of the spinal cord between the levels of C1 and T1 and excludes brachial plexus lesions or injury to peripheral nerves outside the neural canal (American Spinal Cord Injury Association, 1992; Buchanan & Nawoczenski, 1987). Paraplegia, on the other hand, refers to impairment or loss of motor and/or sensory function in the thoracic, lumbar, sacral or coccygeal segments of the spinal cord, secondary to damage of neural elements within the spinal canal (American Spinal Cord Injury Association, 1992; Buchanan & Nawoczenski, 1987). Arm function is spared but, depending on the level of injury, the trunk, legs, and pelvic organs may be involved. The term paraplegia is used to refer to cauda equina and conus medullaris injuries, but not to lumbosacral plexus lesions or injury to peripheral nerves outside the neural canal.

SCI is a traumatic event causing life-changing consequences for the affected individual. The medical and psychological adjustment of persons with SCI has been the subject of considerable research during the past 20 years (Kester, Rothblum, Lobato & Milhaus, 1988). The many problems to which a spinal cord injured person must make adjustments demonstrate the gravity of the psychological processes which occur following spinal cord injury. The individual is confronted with grieving over the physical loss, coping with pain and phantom sensations, alterations in sexual functioning, loss of bladder and bowel control, frustrations of immobilization, loss of vocational goals and earning capacity, feelings of uselessness, role reversals in the family, and the social stigma of being "different" in the public's eye (Hohmann, 1975). In addition, SCI appears to impose a lower stress threshold upon individuals. People may devote so much effort to adjusting to the injury that the incidence of negative events increases their vulnerability to distress (Frank & Elliott, 1987). SCI can deplete coping resources such as financial, recreational and support systems. Personal relationships may be strained as significant others assume new roles with the person. Death of family members or close friends can

be a loss of an important relationship essential to the individual's well-being. These losses, stressful under any circumstance, are especially taxing to the person coping with the acquired disability (Frank & Elliott, 1987).

That so many people whose lives are impacted in this way survive and function at the level of physical and social independence which most people with SCI achieve is an amazing tribute to the flexibility and magnificence of the human spirit (Hohmann, 1975). However, a significant percentage of persons within this population struggle to adapt and cope with such a traumatic event. Studies have shown that 30 to 44% of patients experience a depressive disorder during their rehabilitation (Frank & Elliott, 1987; Fullerton et al., 1981). Another investigation discovered that 13% of this population continue to experience depression long after their rehabilitation is over, a prevalence which is nearly double that for major and minor depression in the U. S. general population (MacDonald, Nielson & Cameron, 1987; Weissman, Myers & Harding, 1978). Additionally, 45% of spinal cord injured individuals in the study by MacDonald and colleagues (1987) scored in the mildly depressed range on the Beck Depression Inventory. Research has demonstrated depressed persons respond to high impact stressful events with more depressive symptoms (Hammen, Mayol, deMayo & Marks, 1986). Thus, a downward spiral occurs as these individuals attempt to cope with their injury. Such incidences of depression among persons with SCI have been shown to be counterproductive to adjustment and rehabilitative efforts (Lawson, 1978).

One way to help alleviate the symptoms of depression is exercise (McCann and Holmes, 1984; McNeil, LeBlanc, & Joyner, 1991; Berger and Owen, 1992; Morris, Steinberg, Sykes, & Salmon, 1990; Doyne, Ossip-Klein, Bowman, Osborn, McDougall-Wilson, & Neimeyer, 1987). Functional electrical stimulation leg cycle ergometry (FES-LCE) is one means for people with SCI to exercise. Individuals' muscles are electrically stimulated which causes them to "pedal" the bicycle. Most recent studies concerning

FES-LCE emphasize its physiological benefits, but some researchers have proposed that FES-LCE may benefit individuals psychologically as well (Alexander and Sipski, 1990).

After a review of current literature, few studies were found which examined regular utilization of FES-LCE for individuals with SCI, including psychological benefits (Alexander, 1988; Alexander & Sipski, 1990; Sipski, Delisa & Schweer, 1989). Only two studies exist which address the psychological effects of FES-LCE utilization (Alexander, 1988; Sipski et al., 1989). Both studies propose that regular FES-LCE utilization has positive psychological effects on individuals with SCI. However, neither study used a control group, a valid or reliable depression inventory and the sample sizes used in each study were small (N=6 and N=47). The purpose of this study is to investigate the proposed psychological benefits of FES-LCE by surveying persons with SCI who are actively participating in a FES-LCE program as well as persons with SCI who are not participating in any form of exercise. Our hope is that this study will provide more evidence to support the efficacy of FES-LCE programs.

CHAPTER 2: LITERATURE REVIEW

Affective, or mood, disorders are characterized by an excessive disturbance of mood, either elated or depressed. The most common patterns include frequent episodes of either manic or depressive behavior, or both. The episodes return repeatedly, but usually clear after weeks or months, with or without treatment. Depression, the most common affective disorder, is a feeling of sadness usually associated with lowered self-esteem (Andreoli, Bennett, Carpenter, Plum & Smith, 1993). It is not a single disease, but seems to involve many variable causes, mechanisms and symptoms. Individuals' thoughts range from feelings of being inadequate and incompetent to delusions that they are evil and feelings of false guilt (American Psychiatric Association, 1987). Patients suffer from physical symptoms as well as psychological depression. Individuals who are depressed often present with disturbances of appetite, rapid weight loss or gain, sleep disorders, psychomotor slowing or agitation and decreased energy. Other indications of depression include feelings of worthlessness, extreme or inappropriate guilt, decreased ability to concentrate, indecisiveness and recurring thoughts of death or suicide or suicide attempts (American Psychiatric Association, 1987). Patients will usually describe feeling sad, down or depressed. Individuals with depression almost always demonstrate loss of interest or pleasure in activities which were previously appealing to them.

Clinical depression, or major depressive disorder (MDD), is defined as "one or more major depressive episodes without a history of either a manic episode or an unequivocal hypomanic episode" (American Psychiatric Association, 1987). The American Psychiatric Association (1987) stated 9 to 26% of adult females and 5 to 12% of adult males in the United States and Europe have MDD. Research has shown that during any 6 month period 2.2 to 3.7% of American adults are depressed (Myers, et al., 1984; Public Health Service, 1992; Weissman et al., 1978). Some individuals diagnosed

with MDD have only one occurrence of symptoms. However, estimates show that greater than 50% of individuals who demonstrate symptoms one time will eventually have another major depressive episode (American Psychiatric Association, 1987). The time between episodes of major depression is highly variable. For some individuals, the episodes of depression are separated by many years, while some people experience clusters of episodes. Still others have episodes occurring more frequently with increasing age (American Psychiatric Association, 1987).

Depression may be assessed in many ways. The most accurate way to assess depression is by an interview with a trained professional. Many scales have been developed to assist professionals and researchers in recognizing depressive symptoms. Scales which have been established as valid and reliable include the Diagnostic Interview Schedule (DIS), the Beck Depression Inventory (BDI), the Center for Epidemiologic Studies-Depression Scale (CES-D) and the Inventory to Diagnose Depression (IDD).

The IDD consists of 22 groups of 5 statements. Each group of statements relates to one depressive symptom and the statements are arranged from least to most severe. The IDD assesses the following symptoms: low mood, decreased energy, psychomotor agitation, psychomotor retardation, decreased interest in usual activities, decreased pleasure in usual activities, decreased libido, guilt, worthlessness, suicidal/death thoughts, decreased concentration, indecisiveness, decreased appetite, weight loss, increased appetite, weight gain, insomnia, hypersomnia, anxiety, hopelessness, irritability, and somatic complaints. Researchers have found that psychiatric inpatients took an average of 15 minutes to complete the IDD (Zimmerman, Coryell, Corenthal & Wilson, 1986).

In two studies, the IDD was found to have a high test-retest reliability (Goldston, O'Hara & Schwartz, 1990; Zimmerman et al., 1986). The IDD has also demonstrated high sensitivity, specificity and correlation with other self assessments (Zimmerman et al., 1986). Zimmerman and Coryell (1988) found the IDD to be a valid scale for diagnosing depression in the general population, while Goldston, O'Hara and Schartz

(1990) determined the IDD to be a valid measure of depressive symptoms in a college sample. A study by Haaga, McDermut and Ahrens (1993) compared the IDD to the BDI to determine discriminate validity. The results indicate a high convergent correlation between the IDD and the BDI for measuring severity of depressive symptoms. Zimmerman and Coryell (1988) compared the IDD with the DIS, an interview designed to be used by lay interviewers. The DIS elicits information similar to that of the IDD. Results of this study demonstrate that both scales are valid measures of depression for non-patient samples.

The IDD was originally developed as a means to more accurately diagnose MDD in a self report manner according to the criteria established in the *Diagnostic and Statistics Manual of Mental Disorders,* 4th edition, Revised (DSM-IV; American Psychiatric Association, 1993). Zimmerman and colleagues (1986) noted the inability of previously established self report depression scales (BDI, CES-D) to accurately diagnose MDD. The IDD differs from other self report depression scales in three ways. First, the IDD's questions are based on the criteria for classification of MDD by DSM-IV standards. For example, the BDI lacks items relating to increases in appetite and resulting weight gain, increases in sleep, slowing or agitation of psychomotor activities, concentration problems and thoughts about death which are non-suicidal. The CES-D fails to include items regarding ideas of suicide, thoughts of death, guilt, agitation and loss of interest in previously enjoyable activities. The CES-D also includes items which are not related to the American Psychiatric Association's diagnostic criteria for MDD. Second, the IDD was designed to determine presence or absence of symptoms as well as severity of symptoms. Like the previously established scales, each statement is graded in severity from 0 to 4. Severity of depression is then determined by adding the scores from each statement. To determine presence or absence of MDD symptoms an item score of 0 means no disturbance, a score of 1 represents subclinical severity, and a score of 2 or more is counted as a symptom. Lastly, unlike the other scales, the IDD addresses the

duration of symptoms. Thus, the IDD is an excellent tool to use with research because it is a relatively quick method for researchers to obtain data about large groups of individuals with depressive symptoms. Furthermore, it does not overemphasize specific clusters of symptoms, but addresses all symptoms of MDD described in the DSM-IV.

Two possible adverse consequences of MDD or depressive symptoms are suicide and alcohol abuse. The death rate from suicide for persons with a spinal cord injury is 2 to 6 times greater than that of the general population (Frisbie & Kache, 1983; Geisler, Jousse, Wynne-Jones & Breithaupt, 1983; Nyquist & Bors, 1967). Several researchers have related emotional disturbances, depression and suicide to poor physical health and chronic diseases (Abram, Moore & Westervelt, 1971; Khan, Herndon & Ahmadian, 1971; MacGregor, 1977; Pless & Roghmann, 1971). In a study of the causes of suicide among persons with orthopedic disabilities, researchers discovered poor health accounted for 30 to 50% of all suicides within this study (Hopkins, 1971). Other causes of suicide in the sample were sexual maladjustment, emotional crises, loss of self-esteem and depression. Clearly, any of these factors may be present in individuals with SCI. A study spanning seven years and following over 1,500 people with SCI revealed that individuals with complete tetraplegia had a suicide rate four times that of the general population while individuals with incomplete tetraplegia had a suicide rate twice that of the general population (Geisler, 1983). A study by Decharme and Freed (1980) showed the majority of suicides occurred five years or more after the initial spinal cord injury, whereas Hopkins' (1971) study reported that 80% of all suicides occur during the first three years after the injury. Despite considerable agreement regarding risk factors for the population as a whole, little has been done to identify risks specific to people with SCI or ways to alleviate or remove those risk factors.

Persons with SCI are at a greater risk for alcohol abuse because they face physical, psychological and vocational difficulties that can include sensory impairment, pain, feelings of dependency, helplessness, hopelessness, depression, alterations in sexual

functioning and reduced opportunities to participate actively and productively in society (Trieschmann, 1988). Alcohol abuse was described as the seventh leading cause of death in a large study of spinal cord injured individuals (Tate, 1993). Other studies have shown that 39 to 62% of persons with SCI sustain alcohol related injuries (Fullerton et al., 1981; O'Donnell et al., 1981). Alcohol abuse by persons with SCI is a concern since it may have been the cause of the disability. Furthermore, it is a harmful and ineffective way for individuals with SCI to deal with their psychological state (e.g. depression) and their physical disability (Tate, 1993). Clearly, these individuals need to find more effective alternatives to help them cope with their disability.

The positive effects of exercise on the physical and psychological status of individuals have been the focus of much research. Byrne and Byrne (1993) reported that 90% of studies regarding exercise and depression support the anti-depressive effects of exercise. Early studies suggested exercise needed to be aerobic in nature to provide positive psychological effects (McCann and Holmes, 1984). More recently, McNeil, LeBlanc, and Joyner (1991) and Berger and Owen (1992) found subjects participating in non-aerobic forms of exercise also reported decreases in depressive symptoms. Also of interest was an investigation by Morris and colleagues (1990) which described the deterioration of emotional state in individuals following deprivation of aerobic exercise compared to a control group which continued to exercise.

The majority of the studies concerning exercise and depression indicates that exercise can help to reduce the severity of depressive symptoms. In addition, most of these studies have used psychological assessment tools which have been proven valid and reliable. However, because research in this area of medicine is fairly new, many weaknesses exist throughout the literature. In 1993, Byrne and Byrne published a review of literature related to exercise and mood. They concluded that much of the current literature does not clearly define the populations used in studies in relation to the general population. Therefore, generalizing the results is inappropriate. In addition, the ability

to apply the results of many studies to the general population is limited because volunteers, often students, are used and many times they are not randomly assigned into groups (Byrne and Byrne, 1993). Furthermore, because many studies do not accurately define depression, comparing the results with other studies is difficult. Although most studies using only a single bout of exercise used a control group, some did not, making analysis of the results imprecise (Byrne and Byrne, 1993). Replication of studies is often challenging because of a lack of consistency regarding the content of exercise programs. The use of a variety of psychological assessment tools also makes comparison of studies difficult. Because most studies rely on self reported measures of depressive symptoms, data may be biased by factors which were not anticipated and consequently not measured. For example, depressive symptoms could decrease due to the exercise itself or to the socialization which may accompany the activity (Byrne & Byrne, 1993; McNeil et al., 1991). Moreover, the literature contains few longitudinal studies which discuss the long term efficacy of exercise on psychological status (Byrne and Byrne, 1993). Lastly, many authors inaccurately quoted or cited literature in their studies making their claims invalid.

In a study by McCann and Holmes (1984) the effects of aerobic exercise on depressive symptoms were assessed on 47 undergraduate females. The women were randomly assigned to an aerobic exercise group, a placebo group or a no treatment group. Individuals in the exercise group participated in a rhythmical aerobics class for one hour, two times per week and exercise outside of class to achieve a total of at least thirty exercise points per week. Those in the placebo group were given verbal and written instructions for muscle relaxation techniques to be performed fifteen to twenty minutes, four days per week and were instructed to begin each relaxation session with five minutes of leisurely walking. Depressive symptoms were assessed using the BDI. Subjects in the aerobic treatment group demonstrated a greater reduction of depressive symptoms than individuals in the placebo and no treatment groups. Therefore, the results indicate that

aerobic activity can help to reduce symptoms of depression. These findings also demonstrated the importance of including a no treatment control group because subjects in the no treatment group reported a reduction of depressive symptoms independent of treatment. The researchers attributed this effect to "regressions of the mean in measurements, changing situational circumstances, and the normal fluctuations in symptomology" (McCann and Holmes, 1984). However, because the presence of depression was determined using the BDI, in which questions are not based on the DSM-IV criteria, the results must be interpreted carefully. This population is probably not representative of the general population because of the increased amount of stress associated with college. Furthermore, individuals in this study volunteered to participate with knowledge that they would probably be participating in exercise. Therefore, subjects in this study may have been more motivated than the sedentary population.

Another study commonly cited in the literature compared aerobic and non-aerobic exercise in terms of their effects on depressive symptoms (Doyne, Ossip-Klein, Bowman, Osborn, McDougall-Wilson, & Neimeyer, 1987). The subjects were 40 females diagnosed with major or minor depressive disorder based on the Research Diagnostic Criteria. Upon completion of baseline data, subjects were matched according to severity of depression established by BDI scores and randomly assigned to one of three conditions; an 8-week aerobic (running) group, a non-aerobic (weight lifting) group or a wait list control group. Subjects were assessed at initial screening, pretreatment, midtreatment and posttreatment. The exercise groups were also assessed one, seven and twelve months following cessation of the study. Results of the study demonstrated clinically and statistically significant decreases in depressive symptoms in the exercising groups compared to the wait list control group. Furthermore, the improvements in severity of symptoms were fairly well retained at the one year follow-up. There were no significant overall differences in depression between the two exercising groups. The authors concluded from the data that improving cardiovascular fitness during exercise is

not necessary in order to demonstrate significant reductions in depression. Again, these results must be interpreted with caution because subjects were not diagnosed according to the universally accepted DSM-IV criteria for MDD.

In 1984, Hughes estimated that greater than 1,000 studies had been performed concerning the relationship between physical and psychological health, with the majority of studies emphasizing exercise as a treatment for depression. Although many weaknesses of studies exist throughout the literature, review of the literature suggests exercise, whether aerobic or non-aerobic, can significantly decrease depressive symptoms in individuals suffering from MDD.

The relationship between affective and endocrine disorders has been a major area of research since clinicians first observed affective disorders in patients with Cushing and Addison diseases (Carroll & Mendels, 1976). The regulation of hypothalamic-pituitary-adrenocortical (HPAC) axis activity is primarily a function of negative feedback by circulating glucocorticoids, but several ascending spinal pathways are important as well (Gann, Dallman & Engeland, 1981; Gibbs, 1969). ß-endorphin is an endogenous opioid peptide released into peripheral blood by the anterior pituitary. Proopiomelanocortin (POMC), the parent compound of both ß-endorphin and corticotropin, is secreted by the pituitary in response to the release of corticotropin-releasing factor from the hypothalamus. Conversely, the release of both of these POMC peptides, ß-endorphin and corticotropin, is inhibited by negative feedback control by cortisol, the peripheral steroid hormone under the control of corticotropin (Culpepper-Morgan, Twist, Petrillo, Soda & Kreek, 1992). Secretion of cortisol follows a circadian rhythm and occurs in intermittent secretory "bursts" (Palmer, 1985). In depressed individuals who are hypersecretors of cortisol, there is an excessive number of daily bursts (Sacher, Hellman, Roffwarg, Halpern, Fukushima & Gallagher, 1973). Thus, an increase in plasma cortisol occurs, mostly during the evening, suppressing the normal circadian rhythm (Palmer, 1985). Disruption of neural pathways by SCI leads to the alteration of HPAC axis

function which causes this hypersecretion of cortisol (Carroll et al., 1980; Carroll, Curtis & Mendels, 1976; Carpenter & Bunney, 1971; Gibbons & McHugh, 1963; Nuller & Ostroumova, 1980). Mood disorders, physical stress, level of lesion and loss of somatic afferents have all been hypothesized to be contributing factors of HPAC axis dysregulation during different stages of recovery following SCI (Claus-Walker & Halstead, 1982; Claus-Walker, Halstead, Carter, Campos & Spencer, 1976; Claus-Walker, Vallbona, Carter & Lipscomb, 1971; McDanial & Sexton, 1971).

In long-term SCI (greater than 12 months post-injury) persistent abnormalities in the HPAC axis exist which may predict abnormal psychological responses to physiological or psychological stress (Culpepper-Morgan, et al., 1992). Research has demonstrated that persons with chronic SCI have low levels of circulating ß-endorphin and depressed circadian rhythm (Palmer, 1985; Twist, Culpepper-Morgan, Ragnarsson, Petrillo & Kreek, 1992). ß-endorphin levels have also been shown to correlate with subjective indexes of depression before any therapeutic interventions have been initiated (Twist, Culpepper-Morgan & Petrillo, 1990). Several studies have revealed that intense aerobic exercise can increase levels of circulating ß-endorphin immediately after exercise (Bortz, Angwin, Mefford, Boarder, Noyce & Barchas, 1981; Brown, Ramirez & Taub, 1978; Carr et al., 1981; Colt, Wardlaw & Frantz, 1981). Investigators have even postulated that ß-endorphin mediates the euphoria, or "runner's high" experienced after endurance exercise (Wildmann, Kruger, Schmole, Neiman & Matthaei, 1986). Sustained changes in mood which correlate with sustained changes in circulating ß-endorphin secondary to exercise have not been demonstrated in the non-depressed individual without SCI. Although the literature supporting ß-endorphin as a mediator of this phenomena has not proven cause and effect, it has demonstrated that exercise results in elevated levels of ß-endorphin (Twist et al., 1992).

Functional electrical stimulation-leg cycle ergometry participants can safely achieve significant aerobic exercise levels and, as a result, their ß-endorphin levels increase

(Pollack, Axen, Spielholz, Levin, Haas, & Ragnarsson, 1989; Twist et al., 1992). Nine subjects from one year to 33 1/2 years post-injury with complete motor and sensory lesions between C5 and T12 participated in a study examining neuroendocrine changes during FES-LCE. Subjects who sustained their SCI less than five years before the study had lower than normal baseline levels of ß-endorphin-like immunoreactivity (BEP-ir) and flattened circadian rhythms. Subjects whose SCI occurred greater than five years prior to the study had higher baseline levels of BEP-ir than subjects who sustained their SCI less than five years before the study with some return to normal circadian rhythmicity. Regardless of the time since injury however, baseline cortisol levels appeared dysregulated. Regular (15-20 min./session, 2-3 x's/wk for 19-30 wks.) FES-LCE caused significantly sustained increases in BEP-ir in all patients and improved the regulation of cortisol. The more strenuous the exercise training, the greater the increases seen in BEP-ir levels (Twist et al., 1992). Thus, FES-LCE may be an effective treatment for spinal cord injured individuals experiencing depression.

Functional electrical stimulation-leg cycle ergometry is the use of low levels of monophasic wave pulses to activate a damaged or disabled nervous system. It bypasses the disabled nervous system by directly stimulating the motor-endpoints of muscles. A FES-LCE system generally consists of three components: a control unit, a stimulator unit interfaced with a computer, and electrodes. The Ergys™ I home rehabilitation system and Regys™ clinical models made by Therapeutic Alliances are lower extremity ergometers that persons with SCI can ride with the assistance of electrical stimulation (see Figure 1). Surface electrodes are placed over the quadriceps, hamstrings and gluteal muscle groups. The subject's feet are secured to the bike's pedals and their legs stabilized by bracing. Sequential stimulation causes contraction of the subject's muscle groups which in turn drives the cranks of the ergometer. Feedback to the computer is based on the crank position of the ergometer so that each muscle group is stimulated at the appropriate time in the crank cycle regardless of pedal speed. The workload can be

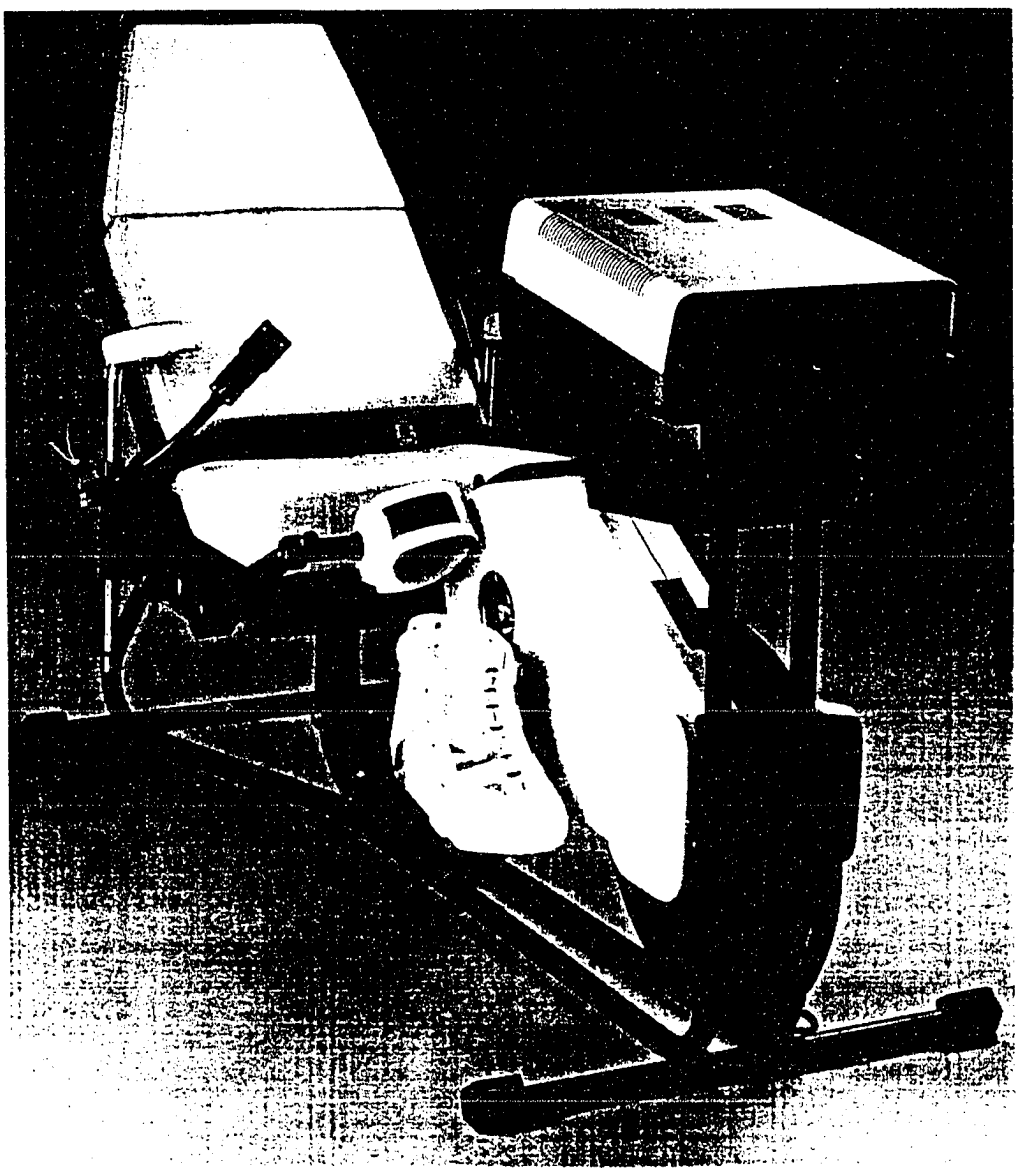

Figure 1: An Ergys™ I home rehabilitation system

adjusted as desired by the individual riding the bike.

Since FES-LCE became commercially available in 1985, many persons with SCI have been able to participate in exercise which incorporates the larger muscle mass of the lower extremities (Faghri, Glaser & Figoni, 1992). Generally accepted benefits of regular (2 to 3 times per week) FES-LCE utilization include increased cardiovascular fitness, respiratory fitness, muscle hypertrophy, muscle strength, muscle endurance and improved local circulation (Faghri, Glaser, Figoni, Miles & Gupta, 1989; Faghri, Glaser & Figoni, 1992; Nash, 1986; Nolte, Helmkamp, Hadley & Curry, 1994; Petrofsky & Phillips, 1983; Petrofsky, Phillips, Heaton & Glaser, 1984; Ragnarsson, Pollack, O'Daniel, Edgar, Petrofsky & Nash, 1988). Researchers have proposed other benefits such as improved range of motion (contracture prevention), decreased spasticity (short term), decreased incidence and severity of decubitus ulcers and urinary tract infections, stabilization of orthostatic hypotension and increased bone density (Claus-Walker, Spencer, Carter, Halstead, Meier III & Campos, 1975; Faghri et al., 1989; Nash, 1986). Although the emphasis of FES-LCE research has clearly been on the physiological benefits derived from FES-LCE, many rehabilitation professionals believe the greatest benefits might be psychological, although very little data to support this proposition exists (Alexander, 1988; Alexander & Sipski, 1990; Sipski, Delisa & Schweer, 1989).

In an effort to find out FES-LCE participants' perceptions of this modality, researchers at the Kessler Institute in New Jersey verbally administered a questionnaire to 47 subjects at their facility. Sixty-two percent of the subjects with paraplegia and 56% of the subjects with tetraplegia reported an "improved self-image" after beginning FES-LCE training. In addition, 56% of the subjects with paraplegia and 77% of the subjects with tetraplegia indicated an "improved appearance" following FES-LCE training (Sipski et al., 1990).

As stated previously, research has not only shown that depression among spinal cord injured individuals is nearly double that for major and minor depression in the U. S.

general population, but also that exercise may be an effective adjunct to the treatment of treating depression (Doyne et al., 1987; MacDonald, et al., 1987; McCann & Holmes, 1984; Weisman, et al., 1978). Due to the nature of their injury, persons who have a SCI have limited opportunities to exercise regularly. For this reason, there has been very little research examining the effects of exercise on the psychological state of individuals with SCI. Therefore, this study has been designed to investigate the effects of regular utilization (2-3 times per week) of an Ergys™ I home rehabilitation unit or a Regys™ clinical unit on the subjective reports of the incidence and severity of symptoms of depression in individuals with SCI. Our hypothesis is that regular participation in a FES-LCE program will improve the psychological state of the spinal cord injured individual. We expect to see lower scores on the Inventory to Diagnose Depression (IDD) in the control group (non-FES-LCE participating subjects) than in the experimental group (those who are participating in a FES-LCE program).

CHAPTER 3: METHODOLOGY

This was a nonequivalent post-test only control design which used a survey methodology. The study compared depressive symptoms of individuals with SCI who were currently exercising using FES-LCE exercise to those who were not participating in any form of exercise. We chose a mail survey over a telephone or personal interview format for many reasons. A mail survey allowed access to a wide geographic region and no interviewer bias was introduced into the study. All respondents received questionnaires with identical wording and participants were able to complete the questionnaire at their convenience. Because of the highly selected group of subjects, we anticipated a higher than average response rate.

Two hundred-fifteen prospective subjects were obtained through the National Spinal Cord Injury Association (NSCIA). Individuals whose names were obtained from the NSCIA constituted the control group. Two hundred-fifteen prospective experimental subjects were obtained from facilities with Ergys™ I home rehabilitation systems and/or Regys™ clinical models. Facilities were identified through the Clinical Functional Electrical Stimulation Center Directory. All subjects at participating FES-LCE centers were given an opportunity to participate in our study. As a result, the experimental group was obtained through chance selection. In addition, the 215 subjects in the control group were randomly selected by a computer from over 1,100 NSCIA members. These methods of selection allowed both groups to be drawn from a large geographic region, increasing the validity of the results. Since there was the possibility that subjects may be members of the NSCIA and involved in a FES-LCE program, a question was included concerning how the respondents received the questionnaire (i.e. through the mail or through a center with an Ergys™ I and/or Regys™ bicycle.) Facilities with Ergys™ I and/or Regys™ stimulators were contacted by telephone to determine participation in the

study. Those centers which agreed with the terms of the study were mailed a survey packet consisting of a cover letter addressed to the supervisor (see Appendix A), cover letters addressed to the participants (see Appendix B), questionnaires (see Appendix C), business size return envelopes and results request postcards (see Appendix D) for each subject participating in the center's FES-LCE program. The cover letter served to introduce the researchers and the research project and included instructions not to place the subject's name on the form. The supervisor of each center distributed individual survey packets to clients participating in the center's FES-LCE program. Subjects returned the completed questionnaire directly to the researchers in the return envelope to ensure subject confidentiality from the center coordinator. Results request postcards were requested to be returned separately from the questionnaires to again ensure anonymity of all participants.

Names and addresses of spinal cord injured members of the NSCIA were obtained from the association. It was assumed that individuals whose names were received from the NSCIA would be willing to cooperate with the study because they had previously agreed with the NSCIA to be solicited. Cover letters (see Appendix E), questionnaires, return envelopes and results request postcards were mailed to these individuals also. Approximately one week after the initial mailing, individuals received a follow-up reminder (see Appendix F) to return the survey. The reminder was sent in an effort to increase the response rate. Since no names were placed on the questionnaires for reasons of confidentiality, there was no way of determining which individuals had returned their questionnaires. Therefore, all subjects received reminders.

Individuals with tetraplegia may not have the motor abilities to write their own responses to the questionnaire. Therefore, another person was permitted to write the subjects' responses to the statements. To eliminate as much outside bias as possible, the questionnaire was designed to be as easy as possible for the subjects to complete independently. The format of the questions was such that respondents could simply

circle their answer or place a mark in a box corresponding with the appropriate response to the question. The survey packets were also mailed in clasp envelopes to facilitate an easier response by maintaining a flat, uncreased form on which the subject could respond.

The survey packet consisted of several questions to establish demographic data and the Inventory to Diagnose Depression (IDD) (see Appendix C). Upon return of the questionnaires, subjects were placed into either the experimental group or the control group. The experimental group consisted of individuals with SCI involved in FES-LCE exercise 2-3 times per week for 30 minute sessions for at least the past 6 months. Exercise duration, exercise frequency and program duration were chosen based on criteria established by the American College of Sports Medicine for acquisition and maintenance of aerobic benefits of exercise for sedentary individuals (American College of Sports Medicine, 1991, Pollack, et al., 1989). These inclusion criteria were chosen to ensure that subjects would be receiving physiologic benefits of exercise, therefore enabling the results of the study to be correlated with previously established research. The control group included individuals with SCI who were not currently involved in any form of aerobic exercise. Individuals less than 18 years old were eliminated from the study to provide a more homogenous sample. Subjects whose injury occurred within one year prior to receiving the questionnaire were eliminated to allow for adjustment to their new lifestyles. Those who had ever used medications and/or sought treatment for psychological disorders were excluded to eliminate factors other than exercise which may contribute to decreased incidence and/or severity of depressive symptoms.

Statistical analysis was performed using Chi-square contingency tables. Incidence of MDD and severity of depressive symptoms were determined using the IDD Hand-Scoring Worksheet. Incidence of MDD was determined by responses to specific items and severity of depressive symptoms was determined by total score (See Appendix G). Data were analyzed concerning incidence and severity of depression with regard to regular FES-LCE participation, regular physical activity, no participation in a FES-LCE program

and no regular physical activity. Physical activity was defined as FES-LCE program participation, participation in other forms of exercise (e. g. arm ergometry) or the ability to walk or stand, with or without assistive devices. Age, time since injury, level of injury (tetraplegia or paraplegia), history of depression, use of depression medications and counseling as a treatment for depression were used as exclusion criteria.

One factor limiting the results of our study is that no control exists for the effects of social contact on psychological state. Also, no normative values have been established for the IDD for individuals with spinal cord injury, possibly limiting the validity of the study.

CHAPTER 4: RESULTS

Two hundred fifteen questionnaires were sent to FES-LCE center coordinators to be distributed to participants and 215 NSCIA members were mailed survey packets. Of the 76 FES-LCE centers contacted in the U.S. and Canada, only 37 had active programs. All 37 centers with active FES-LCE programs agreed to participate (see Appendix H). Responses were received from 131 individuals. Forty-one respondents received the questionnaire from a FES-LCE center, while the remaining 90 individuals received their questionnaires at their home address. This accounted for an over all response rate of 29%. The response rate from FES-LCE participants was 19% and from NSCIA members was 42%.

The mean age of respondents was 41 years. Thirty-two percent of the sample was female and 68% male. Most of the respondents (69%) had paraplegia. The remaining 31% had tetraplegia. The mean time since injury was 10 years. The respondents left various questions unanswered, accounting for the different numbers for the total population for each characteristic. Refer to Table 1 for a summary of demographic data.

The IDD Hand-Scoring Worksheet defined the range of scores required for subjects' placement into the following categories of depression symptom severity: None, None-Minimal, Minimal-Mild, Mild-Moderate, Moderate-Severe and Severe (see Appendix G). Since no respondents scored in the Severe category and only two respondents in the Moderate-Severe group, these categories were combined with the Mild-Moderate severity group to make the category of Mild-Severe severity of depressive symptoms for statistical analysis. In addition, because the category None-Minimal symptoms of depression by the IDD implies the inclusion of "None" or no symptoms of depression are present, those respondents who scored in the None category

Table 1

Summary of Demographic Data for All Respondents

Characteristic	n	Percent	*M*	Range
Age	128	-	40 yrs.	13-83 yrs.
Gender	131	-	-	-
Male	89	68%	-	-
Female	41	32%	-	-
Years Post-Injury	129	-	10 yrs.	.5-35 yrs.
Level of Injury	131	-	-	-
Tetraplegia	41	31%	-	-
Paraplegia	90	69%	-	-
Ethnicity	131	-		-
White	119	91%	-	-
African-American	3	2%	-	-
Hispanic	4	3%	-	-
Asian	0	0%	-	-
American Indian	2	2%	-	-
Other	3	2%	-	-
Degree of Injury	126	-	-	-
Complete	66	52%	-	-
Incomplete	60	48%	-	-
Cause of Injury	131	-	-	-
MVA	56	43%	-	-
Fall	17	13%	-	-
Act of Violence	6	4%	-	-
Recreational	16	12%	-	-
Sports	1	1%	-	-
Other	35	27%	-	-
Marital Status	131	-	-	-
Married	59	45%	-	-
Single	56	43%	-	-
Divorced	16	12%	-	-

were placed within the None-Minimal category.

Eight subjects met the previously established criteria for the experimental group. None of these individuals were determined to have MDD according to the IDD. Thirty-seven respondents met the previously established criteria for the control group. Three of these individuals were diagnosed with MDD by the IDD. In the experimental group, six individuals had None-Minimal symptoms and two had Minimal-Mild symptoms. No experimental group individuals scored high enough to be placed into the Mild-Severe group. In the control group, nineteen individuals had None-Minimal symptoms of depression, fifteen had Minimal-Mild symptoms and four had Mild-Severe symptoms.

Since none of the hypothesized relationships explored through Chi-square contingency table analysis were found to be significant at the $p<0.05$ level, data were analyzed using different exclusion criteria yielding the following interesting results (see Appendix I). A trend emerged between participation in a FES-LCE program and incidence of MDD and severity of depressive symptoms when time since injury and age were used as the only exclusion criteria. The trend indicated that more individuals who did not participate in a FES-LCE program had higher incidence and severity of MDD symptoms. Data analysis indicated that approximately 7% of those who were not participating in a FES-LCE program were diagnosed with MDD while no one in the group of FES-LCE participants were diagnosed with MDD. Results also demonstrated that approximately two thirds of the FES-LCE participants had None-Minimal symptoms while the remaining one third were classified as having symptoms of Minimal-Mild intensity. Approximately one half of those not participating in FES-LCE had symptoms of None-Minimal severity, one third were placed into the Minimal-Mild category and one sixth had Mild-Severe symptoms (see Figure 2).

Another trend was observed when age and time since injury were used as exclusion criteria and only individuals with tetraplegia were included. A statistically significant difference ($p<0.05$) was indicated in severity of depressive symptoms between

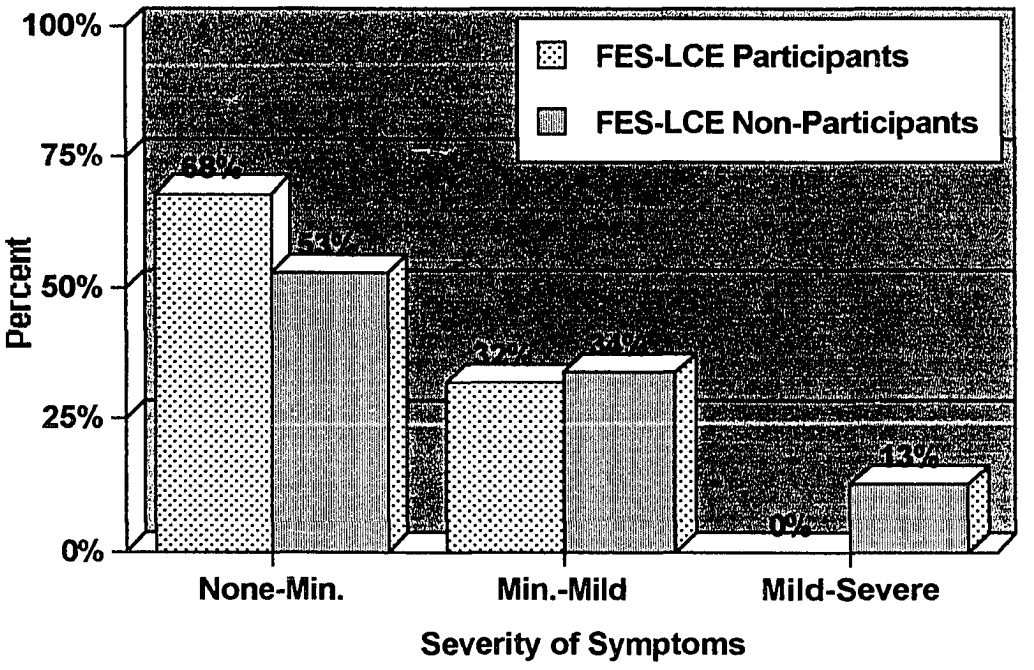

Figure 2: Severity of depressive symptoms in relation to FES-LCE participation with age and time since injury as exclusion criteria.

those participating in a FES-LCE program and those not participating in a FES-LCE program such that those participating in a FES-LCE program were less likely to have greater symptoms of depression. One hundred percent of the individuals riding a Regys™ or Ergys™ I electrical stimulator had None-Minimal symptoms. Approximately one third of those not riding presented in the None-Minimal symptom category while the remaining two thirds scored in the Minimal-Mild range of depressive symptoms (see Figure 3).

Data were also analyzed regarding reported physical activity and incidence of MDD and severity of depressive symptoms. A statistically significant difference ($p<0.05$) was observed between physical activity and presence of MDD when age, time since injury, history of depression, use of depression medication, and counseling as a treatment for depression were used as exclusion criteria. Eight percent of individuals who were not participating in any form of physical activity described above were diagnosed with MDD by the IDD, whereas no one participating in physical activity was classified as depressed according to DSM-IV criteria.

A trend was also found regarding physical activity and symptom severity in the entire sample when age, time since injury, history of depression, use of depression medication, and counseling as a treatment for depression were used as exclusion criteria. Seventy-one percent of those physically active had None-Minimal symptoms, 26% scored in the Minimal-Mild category and only 3% were mildly to severely depressed. In the non-physically active group, 51% were characterized by None-Minimal depressive symptoms, 38% had Minimal-Mild symptoms and 11% were described as mildly to severely depressed (see Figure 4).

Significant differences were also observed ($p<0.01$) between physical activity and not only presence of MDD, but also severity of depressive symptoms when only age and time since injury were used as exclusion criteria. All of those who were involved in physical activity were without MDD while 13% of those not participating in physical

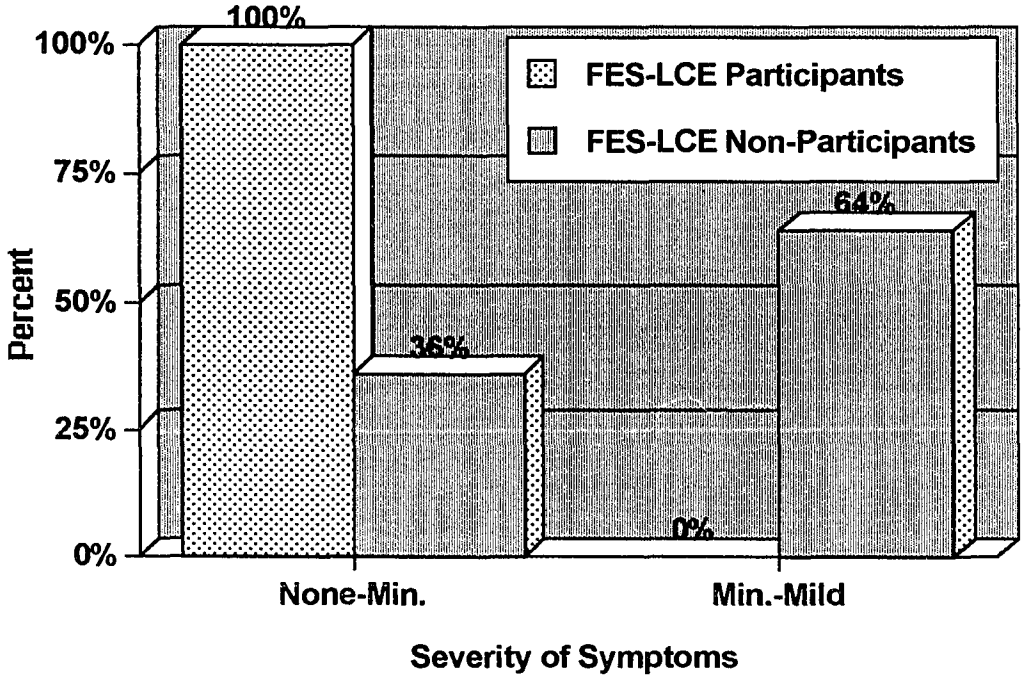

Figure 3: Severity of depressive symptoms among persons with tetraplegia in relation to FES-LCE participation with age and time since injury as exclusion criteria.

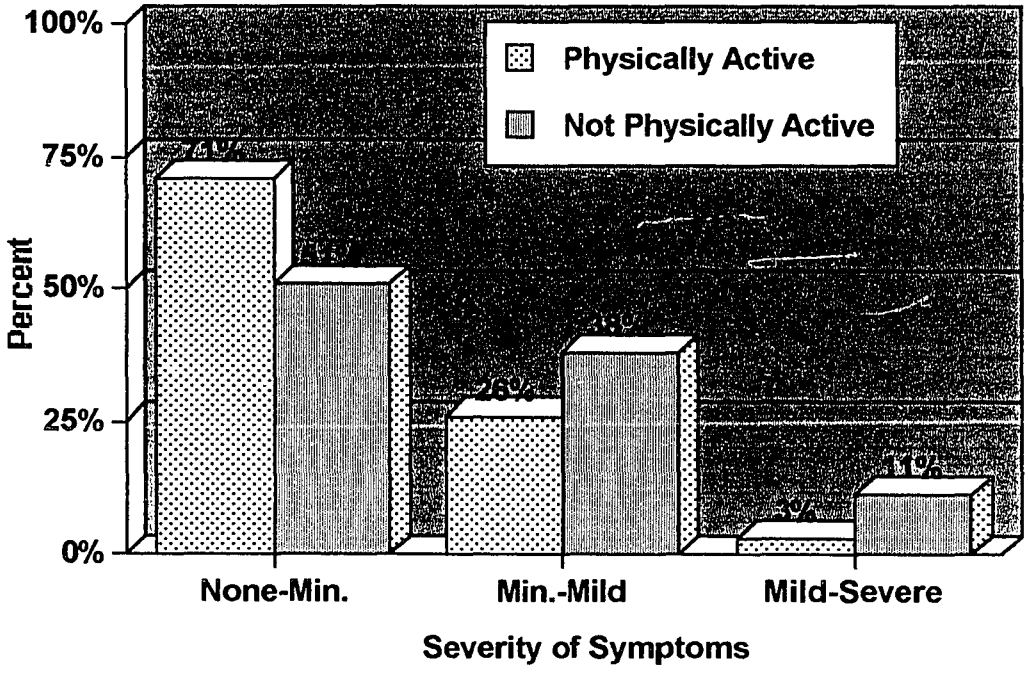

Figure 4: Severity of depressive symptoms in relation to physical activity with age, time since injury, history of depression, use of depression medications, and counseling as a treatment for depression as exclusion criteria.

activity were diagnosed with MDD. Also, 67% of those involved in physical activity demonstrated None-Minimal symptoms of depression, 31% had Minimal-Mild symptoms and only 3% were classified as mildly to severely depressed. severity of symptoms for those not participating in physical activity. Forty-one percent of the individuals not involved in physical activity were categorized as either not depressed or minimally depressed, 39% scored in the Minimal-Mild category and 20% were in the Mild-Severe range (see Figure 5).

Comparison of physical activity with MDD presence and severity of depressive symptoms for subjects with paraplegia yielded statistically significant differences ($p<0.01$) when age and time since injury were used as exclusion criteria. Approximately 15% of those described above who were not physically active had MDD compared to no individuals from the physically active group. Again, significantly more individuals who were not physically active were characterized by Mild-Severe symptoms (24%) compared to 2% of those who were participating in physical activity (see Figure 6).

A final significant difference was found ($p<0.05$) regarding physical activity and presence of MDD in individuals with paraplegia when age, time since injury, history of depression, use of depression medications and counseling were used as exclusion criteria. None of the individuals who were physically active were diagnosed with MDD while almost 12% of those not participating in physical activity had MDD. In addition, a trend appeared between physical activity and severity of symptoms in individuals with paraplegia when these same exclusion criteria were chosen. Only approximately 3% of those who were physically active were mildly to severely depressed compared to 15% of non-physically active individuals (see Figure 7).

In summary, the results indicate a negative correlation between physical activity and incidence of MDD and severity of depressive symptoms for individuals with spinal cord injury when history of depression, use of medications for depression and counseling for depression are not used as exclusion criteria. In general, incidence of MDD and

severity of depressive symptoms are higher for individuals with SCI who are less physically active.

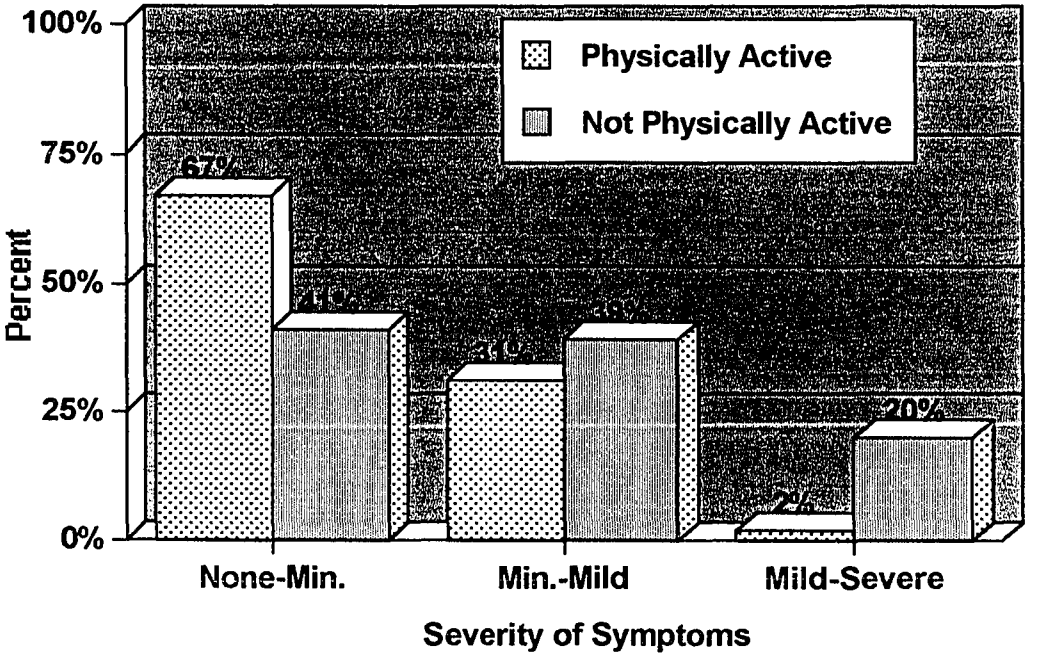

Figure 5: Severity of depressive symptoms in relation to physical activity with age and time since injury as exclusion criteria. $p<0.01$ using Chi-square contingency table procedure.

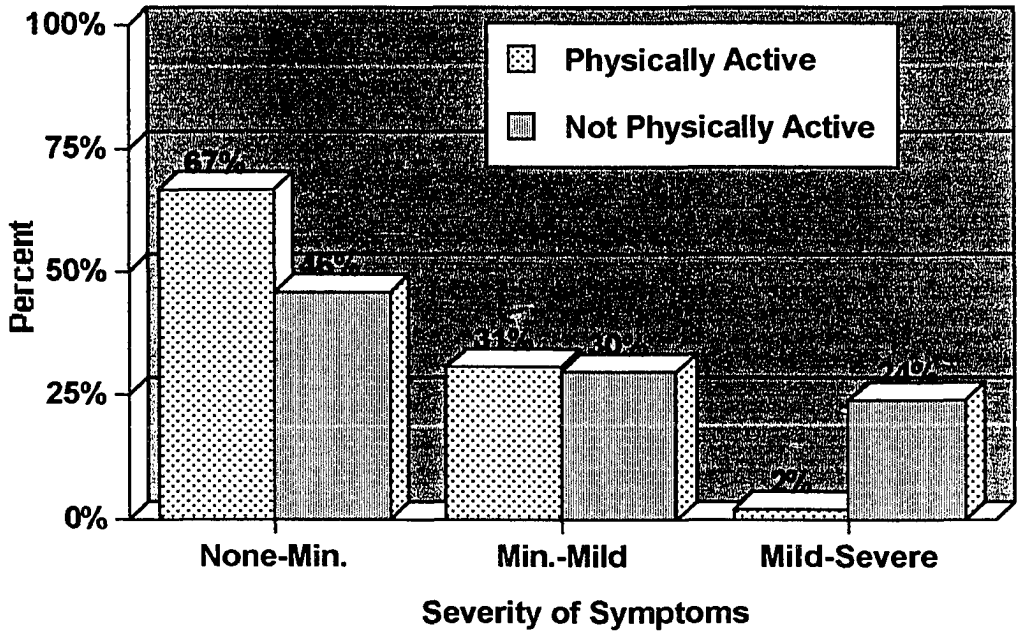

Figure 6: Severity of depressive symptoms among persons with paraplegia in relation to physical activity with age and time since injury as exclusion criteria. $p<0.01$ using Chi-square contingency table procedure.

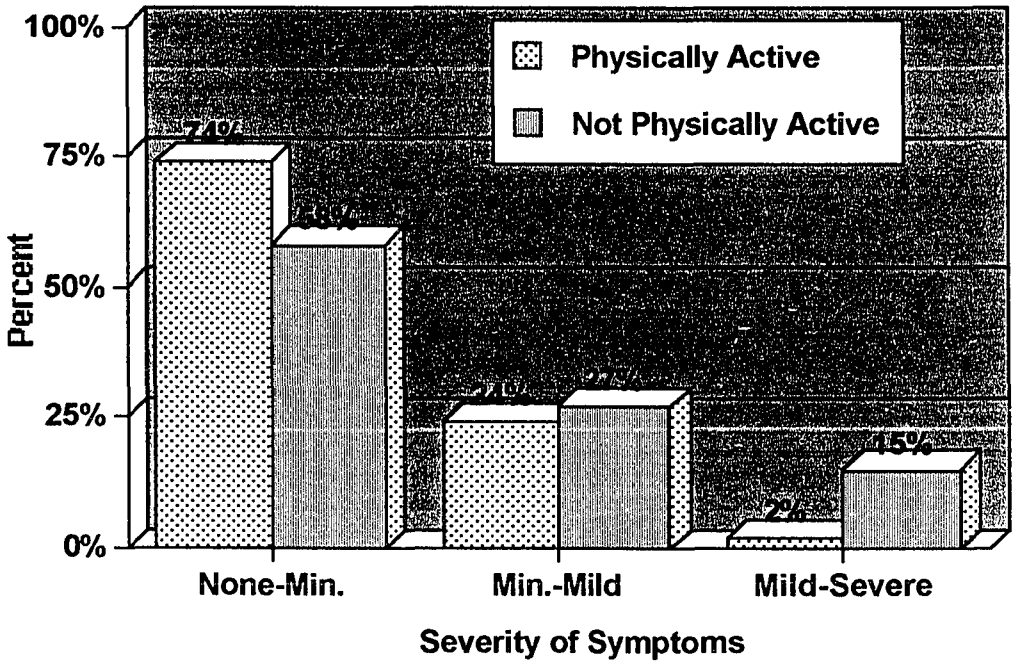

Figure 7: Severity of depressive symptoms among persons with paraplegia in relation to physical activity with age, time since injury, history of depression, use of depression medications and counseling as a treatment for depression as exclusion criteria.

CHAPTER 5: DISCUSSION

Previous research has found the incidence of MDD among those with SCI to be as high as 13% (MacDonald et al., 1987). However, according to the IDD only 4.84% of our sample was diagnosed with MDD. This is only slightly higher than the estimated 2.2 to 3.7% found by researchers in the able bodied population, but much lower than the 13% reported in a study by MacDonald et al. (1987) in persons with SCI whose mean time since injury was 7.3 years (Myers, et al., 1984; Public Health Service, 1992; Weissman et al., 1978). Approximately 34% of our sample scored in the Minimal-Mild depressive symptom severity category This figure is lower, but comparable to previous research performed by MacDonald and colleagues (1987) which revealed that 45% of their sample of spinal cord injured individuals scored in the mildly depressed range on the BDI. There were no subjects in our study who participated in a FES-LCE program or were defined as physically active who were diagnosed as having MDD by the IDD. No subjects participating in a FES-LCE program scored in the Mild-Severe range and only 2.6% of those physically active scored in this range. This trend supports our hypothesis that regular FES-LCE will improve the psychological state of the spinal cord injured individual.

There are a few alternative explanations which could contribute to these results. Individuals participating in a FES-LCE program or regular physical activity, such as wheelchair basketball or standing in a standing frame, involve socialization with other people. The effects of socialization were not controlled in this study and could have affected the results (Byrne & Byrne, 1993; McNeil et al., 1991). In addition, FES-LCE participants receive an increased amount of attendant care. For example, a grade I pressure sore over a subject's sacrum would be easily noticed by the person placing the electrodes on the subject's gluteal muscles prior to FES-LCE. In contrast, a grade I

pressure sore could go unnoticed if someone were not participating in a FES-LCE program. Research has shown that decreased physical health correlates with an increase in the incidence of depression (Chaturvedi, 1987; Khan et al., 1971).

Both aerobic and anaerobic exercise have been correlated with improved mood and psychological state (Doyne et al., 1987). For the spinal cord injured individual, however, the opportunities for physical activity are fewer and often require the assistance of other individuals. FES-LCE appears to be an effective modality for providing aerobic exercise, which can improve one's mood and psychological state. However, this study has demonstrated that FES-LCE may only be one option which provides a means of physical activity for the spinal cord injured individual.

The results of this study emphasize the importance of physical therapists encouraging patients to remain physically active long after physical therapy has ended. Promoting and teaching the spinal cord injured individual to be as physically independent as possible is the responsibility of the health care worker. By promoting physical independence the therapist is also encouraging increases in the amount of daily physical activity. Therefore, it is imperative that therapists promote not only continued physical activity, but also as much physical independence as possible by the patient once physical therapy has terminated.

Several limitations should be considered when interpreting the results of this study. Only eight persons actually met the inclusion criteria for our experimental group. Because of the low overall response rate and number of subjects meeting the inclusion criteria, interpretation of the results in regard to FES-LCE must be made carefully. Significant differences in MDD incidence and severity of depressive symptoms were found in persons with paraplegia, but not in persons with paraplegia. The researchers attribute this to the low overall response rate. The sampling method used may have contributed to these limitations. Statistics have been presented for subjects who met our original inclusion criteria as well as those who did not.

There are a number of possibilities which might have contributed to the low response rate. There was no direct method of contacting experimental group subjects. Therefore, the researchers were required to rely on the center coordinators to distribute the questionnaires. Although each center coordinator agreed to comply with this request, the possibility that not all targeted FES-LCE participants received a questionnaire is probable. Postmarks indicated that questionnaires were returned from at least 17 of the 31 FES-LCE centers which agreed to participate. Center coordinators also often requested extra questionnaires for themselves, human subject review committees and FES-LCE participants that they "might be able to contact." One center replied that they had received a reminder postcard, but not the two questionnaires which were requested. It is possible that other survey packets were lost in the mail as well. Lastly, perhaps depressed individuals simply lacked the motivation to return the questionnaire. Therefore, this may contribute to why the incidence of MDD among persons with SCI in this study was much lower than that found in the study by MacDonald and colleagues. Because of this uncertainty determining exactly how many of the 215 questionnaires ever reached the experimental group subjects is difficult. In addition, nine control group postcard reminders were received and stamped "return to sender" by the post office because the address was incorrect with no forwarding address. No control group questionnaires were returned by the post office. Therefore, there is no way of determining how many of the 215 control group questionnaires actually were received by the subjects.

In addition to the limitations in our sample population, there were also limitations in the construction of the demographic data sheet. Question #10 asked "Are you able to walk with assistive devices?" The respondents' answers to this question did not reveal if they walked with assistive devices regularly and within the last six months, but only that they either did or did not have the ability to do so. Question #11 did not account for persons who might use a tilt table instead of a standing frame, as one respondent

reported. Question #13 did not allow respondents to state that they were participating in FES-LCE 3-4 x's/week or 6-7 x's/week as two respondents reported. This was because the availability of an ergometer was assumed to be limited to 5 x's/week at the FES-LCE centers. However, some respondents owned their own ergometers and therefore had the opportunity to ride up to 7 x's/week. Additionally, question #20 was intended to distinguish between experimental and control group subjects. However, some experimental group subjects actually received their survey packets at home because FES-LCE center coordinators mailed the survey packet to them. Inadvertently, the two groups of survey packets were mailed at different times making it easy to determine which survey packets were intended for each group. Lastly, question #9 was often completed with greater than one option marked. Therefore, the data obtained from this question were imprecise and consequently omitted.

Further research about exercise and depression among those with spinal cord injuries is indicated because of the many questions which remain unanswered. For example, individuals in this study diagnosed with MDD by the IDD may actually be experiencing reactive depression. This normal bereavement also manifests with anxiety symptoms such as initial insomnia, restlessness and autonomic hyperactivity. These reactions occur in response to significant separations and losses such as death, marital separation, romantic disappointment, leaving a familiar environment, forced emigration or civilian catastrophes. Reactive depression does not generally cause MDD (The Merck Manual, 1992). The possibility that subjects were actually experiencing reactive depression could be ruled out by adding questions to the demographic data sheet which inquire about any significant separations or losses the subjects may have recently experienced. There is also another question this study did not attempt to answer, but must be considered: "Is depression the cause of decreased physical activity or is a sedentary lifestyle contributing to a person's depression?" Lastly, the researchers feel that a prospective study is needed which determines the subjects' level of depression

prior to initiating a FES-LCE program and once again after regular FES-LCE utilization has been established.

In further research concerning FES-LCE using a survey methodology, the researchers suggest a follow-up phone call and reminder postcard to center coordinators. This would verify that the center coordinators had received the survey packets and were distributing them. Slope analysis of bar graphs may also be indicated in as well as contingency table analysis. This could possibly better identify trends regarding the incidence of MDD or severity of depressive symptoms and exercise. In addition, some slight modifications to the demographic data sheet attached to the IDD would be helpful. Questions #10 and #11 should be reworded to assess the length of time (months), frequency (x's/week), and duration/session that the subjects participated in these activities. Question #13 should allow people to respond with the options of "3-4 x's/week" and "6-7 x's/week" as well. Question #20 could be reworded or omitted. If omitted, each survey packet could be mailed with the letters "A" or "B" on it to distinguish which group the survey packet was intended. This would assist in determination of response rates. Question #9 should clarify to the respondent to mark only the most appropriate response, as many respondents marked greater than one option. Question #12 could be modified to ask if the respondent was riding an Ergys™ I, Regys™ or both ergometers. This would provide the researchers with more information as to which ergometer is used more clinically. In addition, in response to one respondent's recommendation, the researchers suggest questions #4 and #5 should be separated to allow more space to answer the questions. Lastly, 32 respondents included their results request postcard in the same envelope as their returned IDD and demographic data sheet. Stamps could be placed on the results request postcards to deter respondents from rendering their confidentiality.

There are many concerns and issues revolving around spinal cord injured persons' ability and opportunity to exercise. This study focused on the psychological effects of

FES-LCE on depression in individuals with spinal cord injury. In addition, this study examined the psychological effects of increased physical activity in general by persons with spinal cord injury. The results of this study indicate that FES-LCE, as well as providing physical activity, may have a positive effect on the psychological state of the individuals with SCI. The majority of the literature has found similar results between able-bodied individuals and physically active persons with SCI (MacDonald et al., 1987; McCann & Holmes, 1984). However, there is little research which specifically concentrates on the psychological effects of FES-LCE on individuals with SCI (Sipski et al., 1989). One reason for this may be the limited use of FES-LCE in the U.S. and Canada. Further research concerning the psychological effects of FES-LCE is indicated. The results of this study suggest that more people with SCI could be benefiting from this modality.

REFERENCES

Abram, H. S., Moore, G. L., & Westervelt, F. B. (1971). Suicidal behavior in chronic dialysis patients. American Journal of Psychiatry, 127, 1199-1204.

Alexander, C. J. (1988, September). Psychological effects of a functional stimulation program with spinal cord injured individuals: a pilot study. Paper presented at the American Association of Spinal Cord Injury Psychologists and Social Workers, Las Vegas, NV.

Alexander, C. J., & Sipski, M. C. (1990). Electrical stimulation bicycle ergometry with spinal cord injured patients: Potential medical and psychological benefits. SCI Psychological Process, 3, 18-20.

American College of Sports Medicine. (1991). Guidelines for Exercise Testing and Prescription (4th ed.). Philadelphia, PA: Lea & Febiger.

American Psychiatric Association. (1987). Diagnostic and statistical manual of mental disorders (3rd ed.). Washington DC: Author.

American Psychiatric Association. (1993). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: Author.

American Spinal Cord Association. (1992). Standards for neurological classification of spinal injury patients. (Revised 1992). Chicago, IL: ASIA.

Andreoli, T. E., Bennett, J. C., Carpenter, C. C. J., Plum, F., & Smith, L. H., Jr. (1993). Cecil Essentials of Medicine (3rd ed.). Philadelphia: W. B. Saunders.

Berger, B. G., & Owen, D. R. (1992). Mood alteration with yoga and swimming: Aerobic exercise may not be necessary. Perceptual and Motor Skills, 75, 1331-1343.

Bortz, W. M., Angwin, P., Mefford, I. N., Boarder, M. R., Noyce, N. & Barchas, J. D. (1981). Catecholamines, dopamine, and endorphin levels during extreme exercise. New England Journal of Medicine, 305, 466-467.

Brown, R. S., Ramirez, D. E., & Taub, J. M. (1978). The prescription of exercise for depression. The Physician and Sports Medicine, 6, 34-37, 40-41, 44-45.

Buchanan, L. E., & Nawoczenski, D. A. (Eds.). (1987). Spinal cord injury concepts and management approaches. Baltimore: Williams & Wilkins.

Byrne, A., & Byrne, D. G. (1993). The effect of exercise on depression, anxiety and other mood states: A review. Journal of Psychosomatic Research, 37, 565-574.

Carpenter, W. T., Jr., & Bunney, W. R., Jr. (1971). Adrenal cortical activity in depressive illness. American Journal of Psychiatry, 128, 31-40.

Carr, D. B., Bullen, B. A., Skrinar, G. S., Arnold, M. A., Rosenblatt, M., Beitins, I. Z., Martin, J. B., & McArthur, J. W. (1981). Physical conditioning facilitates the exercise induced secretion of ß-endorphin and ß-lipotropin in women. New England Journal of Medicine, 305, 560-563.

Carroll, B. J., & Mendels, J. (1976). Neuroendocrine regulation in affective disorders. In E. J. Sacher (eds.) Hormones, behavior, and psychopathology (pp. 193-224). New York: Raven Press.

Carroll, B. J., Curtis, G. C., & Mendals, J. (1976). Neuroendocrine regulation in depression: I. limbic system-adrenocortical dysfunction: II. discrimination of depressed from nondepressed patients. Archives of General Psychiatry, 33, 1039-1057.

Carroll, B. J., Schroeder, K., Mukhopadhyay, S., Greden, J. F., Feinberg, M., Ritchie, J., & Tarika, J. (1980). Plasma dexamethasone concentrations and cortisol suppression responses in patients with endogenous depression. Journal of Clinical Endocrinology and Metabolism, 51, 433-437.

Charlifue, S. W., & Gerhart, K. A. (1991). Behavioral and demographic predictors of suicide after traumatic spinal cord injury. Archives of Physical Medicine and Rehabilitation, 72, 488-492.

Chaturvedi, S. K. (1987). Prevalence of chronic pain in psychiatric patients. Pain, 29, 231-237.

Claus-Walker, J., & Halstead, L. S. (1982). Metabolic and endocrine changes in spinal cord injury: III. less quanta of sensory input plus bedrest and illness. Archives of Physical Medicine and Rehabilitation, 63, 628-631.

Claus-Walker, J., Halstead, L. S., Carter, R. E., Campos, R. J., & Spencer, W. A. (1976). Biomechanical responses to intense local cooling in healthy subjects and in subjects with cervical spinal cord injury. Archives of Physical Medicine and Rehabilitation, 57, 50-54.

Claus-Walker, J., Spencer, W. A., Carter, R. E., Halstead, L. S., Meier, R. H., III, & Campos, R. J. (1975). Bone metabolism in quadriplegia: Dissociation between calciuria and hydroxyprolinuria. Archives of Physical Medicine and Rehabilitation, 56, 327-332.

Claus-Walker, J., Vallbona, C., Carter, R. E., & Lipscomb, H. S. (1971). Resting and stimulated endocrine function in human subjects with spinal cord transection. Journal of Chronic Disease, 24, 193-207.

Colt, E. W., Wardlaw, S. L., & Frantz, A. G. (1981). The effect of running on plasma ß-endorphin. Life Science, 28, 1637-1640.

Cooper, K. C. (1968). Aerobics. New York: Bantam Books.

Culpepper-Morgan, J. A., Twist, D. J., Petrillo, C. R., Soda, K. M., & Kreek, M. J. (1992). ß-Endorphin and cortisol abnormalities in spinal cord-injured individuals. Metabolism, 41, 578-581.

Davidoff, G., Roth, E., Thomas, P., Doljanac, R., & Dijkers, M. (1990). Depression among acute spinal cord injury patients: A study utilizing the Zung self rating depression scale. Rehabilitation Psychology, 35, 171-179.

Doyne, E. J., Ossip-Klein, D. J., Bowman, E. D., Osborn, K. M., McDougall-Wilson, I. B., & Neimeyer, R. A. (1987). Running versus weight lifting in the treatment of depression. Journal of Consulting and Clinical Psychology, 55, 748-754.

Ducharme, S. H., & Freed, M. M. (1980). The role of self-destruction in spinal cord injury mortality. SCI Digest, 2, 29-38.

Faghri, P. D., Glaser, R. M., & Figoni, S. F. (1992). Functional electrical stimulation leg cycle ergometer exercise: Training effects on cardiorespiratory responses of spinal cord injured subjects at rest and during submaximal exercise. Archives of Physical and Medical Rehabilitation, 73, 1085-1093.

Faghri, P. D., Glaser, R. M., Figoni, S. F., Miles, D. S., & Gupta, S. C. (1989). Feasibility of using two FNS exercise modes for spinal cord injured patients. Clinical Kinesiology, 43, 62-68.

Frank, R. G., & Elliott, T. R. (1987). Life stress and psychologic adjustment following spinal cord injury. Archives of Physical Medicine and Rehabilitation, 68, 344-347.

Frank, R. G., Kashani, J. H., Wonderlich, S. A., Lising, A., & Viscot, L. R. (1985). Depression and adrenal function in spinal cord injury. American Journal of Psychiatry, 142, 252-253.

Frisbie, J. H., & Kache, A. Increasing survival and changing causes of death in myelopathy patients. (1983). Journal of the American Paraplegia Society, 6, 51-56.

Fuhrer, M. J., Rintala, D. H., Hart, K. A., Clearman, R., & Young, M. E. (1993). Depressive symptomatology in persons with spinal cord injury who reside in the community. Archives of Physical Medicine and Rehabilitation, 74, 255-260.

Fullerton, D. T., Harvey, R. F., Klein, M. H., & Howell, T. (1981). Psychiatric disorders in patients with spinal cord injuries. Archives of General Psychiatry, 38, 1369-1371.

Gans, J. S. (1981). Depression diagnosis in a rehabilitation hospital. Archives of Physical Medicine and Rehabilitation, 62, 386-389.

Geisler, W. O., Jousse, A. T., Wynne-Jones, M., & Breithaupt, D. (1983). Survival in traumatic spinal cord injury. Paraplegia, 21, 364-373.

Gibbons, F. P., & McHugh, P. R. (1963). Plasma cortisol in depressive illness. Journal of Psychiatric Research, 1, 162-171.

Gibbs, F. P. (1969). Central nervous system lesions that block release of ACTH caused by traumatic stress. American Journal of Physiology, 217, 78-83.

Goldston, D. B., O'Hara, M. W., & Schartz, H. A. (1990). Reliability, validity, and preliminary normative data for the inventory to diagnose depression in a college population. Psychological Assessment: A Journal of Consulting and Clinical Psychology, 2, 212-215.

Hammen, C., Mayol, A., deMayo, R., & Marks, T. (1986). Initial symptom levels and life-event-depression relationship. Journal of Abnormal Psychology, 95, 114-122.

Hohmann, G. W. (1975). Psychological aspects of treatment and rehabilitation of the spinal cord injured person. Clinical Orthopaedics and Related Research, 112, 81-88.

Hopkins, M. T. (1971). Patterns of self-destruction among the orthopedically disabled. Rehabilitation Research and Practice Review, 3, 5-16.

Hughes, J. R. (1984). Psychological effects of habitual aerobic exercise: A critical review. Preventive Medicine, 13, 66-78.

Kester, B. L., Rothblum, E. D., Lobato, D., & Milhous, R. L. (1988). Spouse adjustment to spinal cord injury: Long-term medical and psychosocial factors. Rehabilitation Counseling Bulletin, 32, 4-21.

Khan, A. U., Herdon, C. H., & Ahmadian, S. Y. (1971). Social and emotional adaptations of children with transplanted kidneys and chronic hemodialysis. American Journal of Psychiatry, 127, 1194-1198.

Lawson, N. C. (1978). Significant events in the rehabilitation process: The spinal cord patient's point of view. Archives of Physical Medicine and Rehabilitation, 59, 573-579.

MacDonald, M. R., Nielson, W. R., & Cameron, M. P. (1987). Depression and activity patterns of spinal cord injured persons living in the community. Archives of Physical Medicine and Rehabilitation, 68, 339-343.

MacGregor, M. (1977). Juvenile diabetics growing up. Lancet, 1, 944-945.

McCann, I. L., & Holmes, D. S. (1884). Influence of aerobic exercise on depression. Journal of Personality and Social Psychology, 46, 1142-1147.

McDanial, J. W., & Sexton, A. W. (1971). Psychoendocrine functions in relation to level of spinal cord transection. Hormones and Behavior, 2, 56-96.

McNeil, J. K., LeBlanc, E. M., & Joyner, M. (1991). The effect of exercise on depressive symptoms in the moderately depressed elderly. Psychology and Aging, 6, 487-488.

Morris, M., Steinberg, H., Sykes, E. A., & Salmon, P. (1990). Effects of temporary withdrawal from regular running. Journal of Psychosomatic Research, 34, 493-500.

Myers, J. K., Weissman, M. M., Thachler, G. L., Holzer, C. E., Leaf, P. J., Orvaschel, H., Burke, J. D., Kramer, M., & Stoltzman, R. (1984). Six-month prevalence of psychiatric disorders in three communities. Archives of General Psychiatry, 41, 959-967.

Nash, M. S. (1986). Computerized functional electrical stimulation: An emerging rehabilitation. Trends in Rehabilitation, 2, 5-13.

National Spinal Cord Injury Association Statistical Center. (1992). Factsheet No. 1: What is spinal cord injury? And what can we do about it?. Birmingham, AL: Author.

National Spinal Cord Injury Association Statistical Center. (1992). Factsheet No. 2: Spinal cord injury statistical information. Birmingham, AL: Author.

Nolte, S., Helmkamp, R., Hadley, S. & Curry, B. (1994). Effects of a long term programme of exercise on quadriplegics. Unpublished manuscript.

Nuller, J. L.., Ostroumova, M. N. (1980). Resistance to inhibiting effect of dexamethasone in patients with endogenous depression. Acta Psychiatrica Scandinavica, 61, 169-177.

Nyquist, R. H., & Bors, E. (1967). Mortality and survival in traumatic myelopathy during nineteen years, from 1946 to 1965. Paraplegia, 5, 22-48.

O'Donnell, J. J., Cooper, J. E., Gessner, J. E., Shehan, I., & Ashley, J. (1981). Alcohol, drugs and spinal cord injury. Alcohol Health and Research World, 7, 27-29.

Palmer, J. B. (1985). Depression and adrenocortical function in spinal cord injury patients: A review. Archives of Physical Medicine and Rehabilitation, 66, 253-256.

Petrofsky, J. S., & Phillips, C. A. (1983). Active physical therapy: A modern approach to rehabilitation therapy. Journal of Neurologic and Orthopedic Surgery, 4, 165-173.

Petrofsky, J. S., Phillips, C. A., Heaton, H. H., & Glaser, R. M. (1984). Bicycle ergometer for paralyzed muscle. Journal of Clinical Engineering, 9, 13-19.

Pless, I. B., & Roghmann, K. J. (1971). Chronic illness and its consequences: Observations based on three epidemiologic surveys. Journal of Pediatrics, 79, 351-359.

Pollack, S. F., Axen, K., Spielholz, N., Levin, N., Haas, F., & Ragnarsson, K. T. (1989). Aerobic training effects of electrically induced lower extremity exercises in spinal cord injured people. Archives of Physical Medicine and Rehabilitation, 70, 214-219.

Public Health Service. (1992). Estimating the prevalence of mental disorders in U.S. adults from the Epidemiologic Catchment Area Survey. *Public Health Reports*: WDC: Author.

Ragnarsson, K. T., O'Daniel, W., Jr., Edgar, R., Pollack, S., Petrofsky, J., & Nash, M. S. (1988). Clinical evaluation of computerized functional electrical stimulation after spinal cord injury: A multicenter pilot study. Archives of Physical and Medical Rehabilitation, 69, 672-677.

Sacher, E. J. Hellman, L. Roffwarg, H. P., Halpern, F. S., Fukushima, D. K., & Gallagher, T. F. (1973). Disrupted 24-hour patterns of cortisol secretion in psychotic depression. Archives of General Psychiatry, 28, 19-30.

Sipski, M. L., Delisa, J. A., & Schweer, S. (1989). Functional electrical stimulation bicycle ergometry: Patient Perceptions. American Journal of Physical and Medical Rehabilitation, 68, 147-149.

Tate, D. G. (1993). Alcohol use among spinal cord-injured patients. American Journal of Physical Medicine and Rehabilitation, 72, 192-195.

The Bantam Medical Dictionary. (1990). New York, NY: Market House Books Limited.

The Merck Manual of Diagnosis and Therapy. (1992). Rahway, NJ: Merck Research Laboratories.

Trieschmann, R. (1988). Spinal cord injuries: Psychological, social, and vocational rehabilitation. New York: Pergamon Press.

Twist, D. J., Culpepper-Morgan, J. A., Ragnarsson, K. T., Petrillo, C. K., & Kreek, M. J. (1992). Neuroendocrine changes during functional electrical stimulation. American Journal of Physical and Medical Rehabilitation, 71, 156-163.

Twist, D. J., Culpepper-Morgan, J., & Petrillo, C. R. (1990). Neuroendocrine parameters in spinal cord-injured (SCI) involved in a muscle stimulated (REGYS I) exercise program. ASIA: Abstract Digest, May.

Weissman, M. M., Myers, J. K., & Harding, P. S. (1978). Psychiatric disorders in US urban community. American Journal of Psychiatry, 25, 459-462.

Wildmann, J., Kruger, A., Schmole, M., Neiman, J., & Matthaei, H. (1986). Increase of circulating beta-endorphin-like immunoreactivity correlates with the change in feeling of pleasantness after running. Life Science, 38, 997-1003.

Zimmerman, M., & Coryell, W. (1988). The validity of a self-report questionnaire for diagnosing major depressive disorder. Archives of General Psychiatry, 45, 738-740.

Zimmerman, M., Coryell, W., Corenthal, C., & Wilson, S. (1986). A self-report scale to diagnose major depressive disorder. Archives of General Psychiatry, 43, 1076-1081.

APPENDIX A
Cover letter to FES-LCE Center Coordinator

Grand Valley State University
Department of Physical Therapy
c/o Helmkamp and Nolte Thesis
Fieldhouse 152
Allendale, Michigan 49401
October 26, 1994

Dear FES-LCE Center Coordinator:

Thank you for your positive response and decision to participate in our study. Enclosed you will find a cover letter, questionnaire, return envelope and postcard to be distributed to each participant in your FES-LCE program taking part in this study.

At this point your involvement with this study ends, as individuals are responsible for returning their own questionnaires.

In appreciation of your participation, we will be happy to send you a copy of the results of this study. You can expect to receive the results during May or June 1995.

Again thank you for your help with this study.

Sincerely,

Renee Helmkamp, S.P.T.

Scott Nolte, S.P.T.

Jane Toot, PT, Ph.D.
Director of Physical Therapy
Grand Valley State University

You may direct any questions or comments to the above address or call Renee Helmkamp at (616) 895-9443.

APPENDIX B
Cover letter to FES-LCE Participant

Grand Valley State University
Department of Physical Therapy
c/o Helmkamp and Nolte Thesis
Fieldhouse 152
Allendale, Michigan 49401
October 26, 1994

Dear FES-LCE Participant:

We are Physical Therapy students from Grand Valley State University in Allendale, Michigan. As a requirement for completion of a Masters of Science degree, we are performing research which focuses on effects of functional electrical stimulation leg cycle ergometry (FES-LCE)exercise on depression in individuals with spinal cord injury.

You have been chosen to participate in this study because of your participation in a FES-LCE program. By completing and returning the enclosed questionnaire, you are giving your consent to include the information you provide in this study. Reports, publications in professional scientific journals and subsequent studies will not discuss individual responses but will include only group data. **All completed questionnaires will remain anonymous and confidential.** The questionnaire should take approximately 20 minutes for you to complete .

If you choose to complete the questionnaire, please return it in the attached postage-paid envelope **no later than November 25, 1994.** To ensure anonymity, please **DO NOT** place your name anywhere on the questionnaire. If you wish to receive the results of this study, you may complete and return the enclosed postcard **separate** from your questionnaire (once again to ensure anonymity).

Thank you in advance for your prompt response and participation in this study. We realize your time is valuable and appreciate your help with our research.

Sincerely,

Renee Helmkamp, S.P.T.

Scott Nolte, S.P.T.

Jane Toot, PT, Ph.D.
Director of Physical Therapy
Grand Valley State University

You may direct any questions or comments to the above address or call Renee Helmkamp at (616) 895-9443.

APPENDIX C
Demographic Data Sheet and IDD
(Questionnaire)

Please place a mark in the appropriate box(es) or circle the appropriate answer and fill-in the blank lines. If you are unable to complete this questionnaire independently, you may have someone assist you with it. Once completed, please place it in the attached envelope and return it by **November 25, 1994**. Thank you very much.

1. Ethnicity:
   - ❒ White
   - ❒ African-American
   - ❒ Hispanic
   - ❒ Asian
   - ❒ American Indian
   - ❒ Other
2. What is your date of birth:_____
3. Gender:
   - ❒ Male
   - ❒ Female
4. What was the date of your injury:_____
5. What is your level of injury (example: C5 or C5/C6):_____
6. Is your injury:
   - ❒ Complete
   - ❒ Incomplete
7. What was the cause of your injury:
   - ❒ Motor Vehicle Accident
   - ❒ Fall
   - ❒ Act of Violence
   - ❒ Recreational Activity_____
   - ❒ Sports
   - ❒ Other_____
8. Are you presently:
   - ❒ Married
   - ❒ Single
   - ❒ Divorced
9. Are you currently:
   - ❒ Employed
   - ❒ Volunteering
   - ❒ Unemployed
   - ❒ Attending School
10. Are you able to walk with assistive devices?
    - ❒ Yes
    - ❒ No
11. Do you stand regularly (2-3 times/week) in a standing frame?
    - ❒ Yes
    - ❒ No

12. Are you presently riding a Regys™ or Ergys™ bicycle?
    - ❒ Yes
    - ❒ No
13. If so, how many times/week?
    - ❒ 1 time/week
    - ❒ 2-3 times/week
    - ❒ 4-5 times/week
    - ❒ Not applicable
14. How long have you been riding a Regys™ or Ergys™ bicycle at the above frequency?
    - ❒ Less than 6 months
    - ❒ Between 6-12 months
    - ❒ Longer than 12 months
    - ❒ Not applicable
15. How long do you ride the Regys™ or Ergys™ bicycle each session?
    - ❒ Less than 30 minutes
    - ❒ 30 minutes
    - ❒ Longer than 30 minutes
    - ❒ Not applicable
16. Have you participated regularly (2-3 times/week) in any other forms of exercise (Ex. wheelchair basketball, wheelchair racing, arm ergometry, weight lifting) within the last 6 months?
    - ❒ Yes
    - ❒ No

    If yes, what?_____
17. Have you ever had professional counseling specifically for clinical depression other than counseling provided during the first year after your injury?
    - ❒ Yes
    - ❒ No
18. Have you ever taken prescription medicine specifically for clinical depression other than during the first year after your injury?
    - ❒ Yes
    - ❒ No
19. Do you have a history of depression before the time of your injury?
    - ❒ Yes
    - ❒ No
20. How did you receive this questionnaire?
    - ❒ Through the mail at your present home address
    - ❒ Through a facility which has a Regys™ or Ergys™ bicycle

APPENDIX D
Results Request Postcard

Dear Renee and Scott,

Yes, I would like to receive the results of this research study. I understand that the results will not be available until mid-June, but am willing to patiently wait! Please send them to me at the following address:

Name_____

Address_____

City, State and Zip Code_____

Thank you.

APPENDIX E
Cover letter to National Spinal Cord Injury Association Members

Grand Valley State University
Department of Physical Therapy
c/o Helmkamp and Nolte Thesis
Fieldhouse 152
Allendale, Michigan 49401
October 26, 1994

Dear National Spinal Cord Injury Association Member:

We are Physical Therapy students from Grand Valley State University in Allendale, Michigan. As a requirement for completion of a Masters of Science degree, we are performing research which focuses on effects of functional electrical stimulation leg cycle ergometry (FES-LCE) exercise on depression in individuals with spinal cord injury.

You have been chosen to participate in this study because of your membership in the National Spinal Cord Injury Association. By completing and returning the enclosed questionnaire, you are giving your consent to include the information you provide in this study. Reports, publications in professional scientific journals and subsequent studies will not discuss individual responses but will include only group data. **All completed questionnaires will remain anonymous and confidential.** The questionnaire should take approximately 20 minutes for you to complete.

If you choose to complete the questionnaire, please return it in the attached postage-paid envelope **no later than November 25, 1994.** To ensure anonymity, please **DO NOT** place your name anywhere on the questionnaire or return envelope. If you wish to receive the results of this study, you may complete and return the enclosed postcard **separate** from your questionnaire (once again to ensure anonymity).

Thank you in advance for your prompt response and participation in this study. We realize your time is valuable and appreciate your help with our research.

Sincerely,

Renee Helmkamp, S.P.T.

Scott Nolte, S.P.T.

Jane Toot, PT, Ph.D.
Director of Physical Therapy
Grand Valley State University

You may direct any questions or comments to the above address or call Renee Helmkamp at (616) 895-9443.

APPENDIX F
Reminder Postcard
Postcard 1: Experimental Group

Dear FES-LCE Coordinator,

This is just a note reminding you to have your FES-LCE participants send in their questionnaires as soon as possible. If they have already, we appreciate their prompt response. However, if some have chosen not to return their questionnaire, please urge them to give it serious thought and reconsider their participation in this study. If any of them have lost or misplaced their questionnaire and would still like to participate, let us know and we'll mail you another copy.

Sincerely,

Renee Helmkamp, S.P.T.

Scott Nolte, S.P.T.

Reminder Postcard
Postcard 2: Control Group

Dear Sir or Madam,

This is just a note reminding you to send in your questionnaire as soon as possible. If you have already, thank you. We appreciate your prompt response. However, if you have chosen not to return your questionnaire, please give it serious thought and reconsider your participation in this study. If you have lost or misplaced the questionnaire and would still like to participate, let us know and we'll mail you another copy.

Sincerely,

Renee Helmkamp, S.P.T.

Scott Nolte, S.P.T.

APPENDIX H
Participating FES-LCE Facilities

The Challenge Center
240 South Magnolia Blvd.
El Cajon, CA 92020

PEERS Program
8912 Olympic Blvd.
Beverly Hills, CA 90211

Rancho Los Amigos Medical Center
Comarr Physical Therapy Dept.
7601 E. Imperial Highway
Downey, CA 90242

Petrofsky Center
13765 Alton Parkway
Suite E
Irvine, CA 92718

Newington Children's Hospital
181 East Cedar St.
Newington, CT 06111

Norwalk Hospital
24 Stevens St.
Norwalk, CT 06850

Physical Therapy Rehabilitation Center
of Coral Springs
9703 W. Sample Rd.
Coral Springs, FL 33065

Sea Pines Rehabilitation Hospital
101 East Florida Ave.
Melborne, FL 32901

Department of Orthopedics
University of Miami
Jackson Medical Center
P.O. Box 016960
Miami, FL 33101

Covenant Medical Center
3421 West 9th
Waterloo, IA 50702

Marianjoy Rehabilitation Hospital
26 W. 171 Roosevelt Rd.
Wheaton, IL 60189

University Hospital of Boston
Physical Therapy Dept.-SCI Unit
88 East Newton
Boston, MA 02118

Montebello Rehabilitation Hospital
2201 Argonne Drive
Baltimore, MD 21218

Medical Illness Counseling Center
Suite 530
2 Wisconsin Circle
Chevy Chase, MD 20815

Grand Valley State University
School of Health Sciences
148 Lake Michigan Hall
Allendale, MI 49401

The Michigan Institute for Independent
Living
1640 Green Rd.
Ann Arbor, MI 48105

Rehabilitation Institute
Physical Therapy Dept.
3011 Baltimore
Kansas City, MO 64108

St. John's Rehabilitation Center
St. John's Mercy Hospital
615 S. New Ballas Rd.
St. Louis, MO 63141

Northeast Rehabilitation Hospital
70 Butler St.
Salem, NH 03079

Universal Institute
383 Ridgedale Ave.
East Hanover, NJ 07936

J.F.K. Medical Center
Johnson Rehabilitation Institute
Outpatient Physical Therapy Dept.
65 James St.
P.O. Box 3059
Edison, NJ 08818

Kessler Institute for Rehabilitation
Outpatient Physical Therapy Dept.
1199 Pleasant Valley Way
West Orange, NJ 07052

V.A. Medical Center
Physical Medicine and Rehabilitation
2100 Ridgecrest Dr., S.E.
Albuquerque, NM 87111

V.A. Medical Center
130 West Kingsbridge Rd.
Bronx, NY 10468-3904

Erie County Medical Center
Outpatient Physical Therapy
462 Grider St.
Buffalo, NY 14215

Asphalt Green
Mount Sinai Medical Center
555 East 90th St.
New York, NY 10128

Ohio State University
Department of Physical Medicine
480 West 9th Ave.
Dodd Hall, Room 2054
Columbus, OH 43210-1290

Institute for Rehabilitation, Research
and Medicine
3171 Research Blvd.
Kettering, OH 45420

Allied Services
Outpatient Physical Therapy Dept.
P.O. Box 1103
475 Morgan Highway
Scranton, PA 18501

Fulton County Medical Center
216 S. First St.
McConnellsburg, PA 17233

Magee Rehabilitation Hospital
Physical Therapy Dept.
6 Franklin Plaza
Philadelphia, PA 19102

University Hospital Rehabilitation Center
at Hershey Medical Center
Physical Therapy Dept.
600 University Dr.
Hershey, PA 17033

Rehabilitation Hospital of San Antonio
9119 Cinnamon Hill
San Antonio, TX 78240

Sheltering Arms Rehabilitation Hospital
1311 Palmyra Ave.
Richmond, VA 23227-4418

Providence Hospital
2940 W. Marine View Dr.
Everett, WA 98201

University of Alberta
WI-67
Van Vliet Complex
Edmonton, Alberta, Canada T6G2H9

St. Joseph's General Hospital
Physiotherapy Dept.
Box 3257
Thunder Bay, Ontario, Canada P7B5G7

APPENDIX I
Contingency Table Analysis

Coded Chi-Square X_1: Ride Regys/Ergys? Y_1: Major Depressive Dis...

Summary Statistics

DF:	1	
Total Chi-Square:	.695	p = .4045
G Statistic:	•	
Contingency Coefficient:	.123	
Phi:	.124	
Chi-Square with continuity correction:	.003	p = .9584

Observed Frequency Table

	Yes	No	Totals:
Yes	0	3	3
No	8	34	42
Totals:	8	37	45

Expected Values

	Yes	No	Totals:
Yes	.53	2.47	3
No	7.47	34.53	42
Totals:	8	37	45

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10
AND	Able to Walk?	No
AND	Able to Stand?	No
AND	FES-LCE Frequency	2-3 x's/wk, 4-5 x's/wk, Not Applicable
AND	Program Duration	6-12 months, > 12 months, Not Applicable
AND	Session Duration	30 minutes, > 30 minutes, Not Applicable
AND	Other Exercise?	No
AND	Counseling?	No
AND	Medications?	No
AND	Depression Hx?	No

Coded Chi-Square X_1: Ride Regys/Ergys? Y_1: MDD Severity

Summary Statistics

DF:	2
Total Chi-Square:	1.832 p = .4001
G Statistic:	•
Contingency Coefficient:	.198
Cramer's V:	.202

Observed Frequency Table

	Yes	No	Totals:
None-Min.	6	19	25
Min.-Mild	2	14	16
Mild-Severe	0	4	4
Totals:	8	37	45

Expected Values

	Yes	No	Totals:
None-Min.	4.44	20.56	25
Min.-Mild	2.84	13.16	16
Mild-Severe	.71	3.29	4
Totals:	8	37	45

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10
AND	Able to Walk?	No
AND	Able to Stand?	No
AND	FES-LCE Frequency	2-3 x's/wk, 4-5 x's/wk, Not Applicable
AND	Program Duration	6-12 months, > 12 months, Not Applicable
AND	Session Duration	30 minutes, > 30 minutes, Not Applicable
AND	Other Exercise?	No
AND	Counseling?	No
AND	Medications?	No
AND	Depression Hx?	No

Coded Chi-Square X_1: Ride Regys/Ergys? Y_1: MDD Severity

Summary Statistics

DF:	2
Total Chi-Square:	5.689 p = .0582
G Statistic:	•
Contingency Coefficient:	.209
Cramer's V:	.214

Observed Frequency Table

	Yes	No	Totals:
None-Min.	25	46	71
Min.-Mild	12	30	42
Mild-Severe	0	11	11
Totals:	37	87	124

Expected Values

	Yes	No	Totals:
None-Min.	21.19	49.81	71
Min.-Mild	12.53	29.47	42
Mild-Severe	3.28	7.72	11
Totals:	37	87	124

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10

Coded Chi-Square X_1: Ride Regys/Ergys? Y_1: Major Depressive Dis...

Summary Statistics

DF:	1	
Total Chi-Square:	2.681	p = .1015
G Statistic:	•	
Contingency Coefficient:	.145	
Phi:	.147	
Chi-Square with continuity correction:	1.393	p = .2379

Observed Frequency Table

	Yes	No	Totals:
Yes	0	6	6
No	37	81	118
Totals:	37	87	124

Expected Values

	Yes	No	Totals:
Yes	1.79	4.21	6
No	35.21	82.79	118
Totals:	37	87	124

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10

Coded Chi-Square X_1: Ride Regys/Ergys? Y_1: MDD Severity

Summary Statistics

DF:	1	
Total Chi-Square:	4.773	p = .0289
G Statistic:	•	
Contingency Coefficient:	.491	
Phi:	.564	
Chi-Square with continuity correction:	2.558	p = .1097

Observed Frequency Table

	Yes	No	Totals:
None-Min.	4	4	8
Min.-Mild	0	7	7
Totals:	4	11	15

Expected Values

	Yes	No	Totals:
None-Min.	2.13	5.87	8
Min.-Mild	1.87	5.13	7
Totals:	4	11	15

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10
AND	Able to Walk?	No
AND	Able to Stand?	No
AND	FES-LCE Frequency	2-3 x's/wk, 4-5 x's/wk, Not Applicable
AND	Program Duration	6-12 months, > 12 months, Not Applicable
AND	Session Duration	30 minutes, > 30 minutes, Not Applicable
AND	Other Exercise?	No
AND	Counseling?	No
AND	Medications?	No
AND	Depression Hx?	No
AND	Level of Injury	Tetraplegia

Coded Chi-Square X_1: Physical Activity? Y_1: Major Depressive Dis...

Summary Statistics

DF:	1	
Total Chi-Square:	5.184	p = .0228
G Statistic:	•	
Contingency Coefficient:	.223	
Phi:	.229	
Chi-Square with continuity correction:	2.792	p = .0947

Observed Frequency Table

	Yes	No	Totals:
Yes	0	3	3
No	62	34	96
Totals:	62	37	99

Expected Values

	Yes	No	Totals:
Yes	1.88	1.12	3
No	60.12	35.88	96
Totals:	62	37	99

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10
AND	Counseling?	No
AND	Medications?	No
AND	Depression Hx?	No

Coded Chi-Square X_1: Physical Activity? Y_1: MDD Severity

Summary Statistics

DF:	2
Total Chi-Square:	4.708 p = .095
G Statistic:	4.63
Contingency Coefficient:	.213
Cramer's V:	.218

Observed Frequency Table

	Yes	No	Totals:
None-Min.	44	19	63
Min.-Mild	16	14	30
Mild-Severe	2	4	6
Totals:	62	37	99

Expected Values

	Yes	No	Totals:
None-Min.	39.45	23.55	63
Min.-Mild	18.79	11.21	30
Mild-Severe	3.76	2.24	6
Totals:	62	37	99

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10
AND	Counseling?	No
AND	Medications?	No
AND	Depression Hx?	No

Coded Chi-Square X_1: Physical Activity? Y_1: Major Depressive Dis...

Summary Statistics

DF:	1	
Total Chi-Square:	10.691	p = .0011
G Statistic:	•	
Contingency Coefficient:	.282	
Phi:	.294	
Chi-Square with continuity correction:	8.046	p = .0046

Observed Frequency Table

	Yes	No	Totals:
Yes	0	6	6
No	78	40	118
Totals:	78	46	124

Expected Values

	Yes	No	Totals:
Yes	3.77	2.23	6
No	74.23	43.77	118
Totals:	78	46	124

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10

Coded Chi-Square X_1: Physical Activity? Y_1: MDD Severity

Summary Statistics

DF:	2
Total Chi-Square:	13.276 p = .0013
G Statistic:	13.27
Contingency Coefficient:	.311
Cramer's V:	.327

Observed Frequency Table

	Yes	No	Totals:
None-Min.	52	19	71
Min.-Mild	24	18	42
Mild-Severe	2	9	11
Totals:	78	46	124

Expected Values

	Yes	No	Totals:
None-Min.	44.66	26.34	71
Min.-Mild	26.42	15.58	42
Mild-Severe	6.92	4.08	11
Totals:	78	46	124

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10

Coded Chi-Square X_1: Physical Activity? Y_1: Major Depressive Dis...

Summary Statistics

DF:	1	
Total Chi-Square:	8.216	p = .0042
G Statistic:	•	
Contingency Coefficient:	.298	
Phi:	.313	
Chi-Square with continuity correction:	5.733	p = .0167

Observed Frequency Table

	Yes	No	Totals:
Yes	0	5	5
No	51	28	79
Totals:	51	33	84

Expected Values

	Yes	No	Totals:
Yes	3.04	1.96	5
No	47.96	31.04	79
Totals:	51	33	84

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10
AND	Level of Injury	Paraplegia

Coded Chi-Square X_1: Physical Activity? Y_1: MDD Severity

Summary Statistics

DF:	2
Total Chi-Square:	10.837 p = .0044
G Statistic:	11.272
Contingency Coefficient:	.338
Cramer's V:	.359

Observed Frequency Table

	Yes	No	Totals:
None-Min.	34	15	49
Min.-Mild	16	10	26
Mild-Severe	1	8	9
Totals:	51	33	84

Expected Values

	Yes	No	Totals:
None-Min.	29.75	19.25	49
Min.-Mild	15.79	10.21	26
Mild-Severe	5.46	3.54	9
Totals:	51	33	84

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10
AND	Level of Injury	Paraplegia

Coded Chi-Square X_1: Physical Activity? Y_1: MDD Severity

Summary Statistics

DF:	2
Total Chi-Square:	3.866 p = .1447
G Statistic:	3.907
Contingency Coefficient:	.239
Cramer's V:	.246

Observed Frequency Table

	Yes	No	Totals:
None-Min.	28	15	43
Min.-Mild	9	7	16
Mild-Severe	1	4	5
Totals:	38	26	64

Expected Values

	Yes	No	Totals:
None-Min.	25.53	17.47	43
Min.-Mild	9.5	6.5	16
Mild-Severe	2.97	2.03	5
Totals:	38	26	64

Range Restrictions

	Column Name:	Restriction:
AND	Age	18-25, 26-35, 36-45, 46-55, 56-65, 66+
AND	Years Post-Injury	1-5, 6-10, >10
AND	Level of Injury	Paraplegia
AND	Counseling?	No
AND	Medications?	No
AND	Depression Hx?	No

AUTOBIOGRAPHICAL STATEMENTS

The idea for this research project originated from clinical observations made while assisting persons riding an Ergys™ I home rehabilitation system. The primary researchers involved in the administration of the study collectively have over 400 hours of clinical experience at two facilities with FES-LCE programs. During this clinical exposure, the researchers were repeatedly impressed with the positive attitudes seen in participants in the FES-LCE programs. The researchers believe in the positive benefits of exercise and encourage all individuals to participate in some form of exercise.

Renee Christner is a physical therapy student completing her final year of study for her entry level master's degree at Grand Valley State University. She received her B.S. in Health Science from Grand Valley in 1993. Upon graduation, Renee will be employed by Parkview Memorial Hospital in Fort Wayne, Indiana. She and her husband Tim are expecting their first child in August 1995 and will be residing in Avilla, Indiana.

Scott Nolte received his Bachelor of Science degree in Biomedical Science Pre-Physical Therapy from Ohio University in 1993. Scott will receive his Master of Science degree in Physical Therapy from Grand Valley State University in April of 1995. After graduation, Scott plans to take a month "off" to enjoy a little rest and relaxation after six great, but very long years. Once fully recuperated, Scott plans to find a job somewhere. His future career aspirations include the possibility of pursuing research in exercise physiology.