Exercise Rehabilitation After Spinal Cord Injury

By

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ABSTRACT

Spinal cord injury (SCI) is a debilitating event that leads to either complete or partial paralysis, sensory loss and loss of autonomic control below the level of neurological interruption. Consequent to the physiological changes that accompany the sustenance of a SCI, many affected individuals experience increased risk of developing cardiovascular disease. In addition, although not experienced by all individuals with SCI, decreased quality of life and depression are more common in these individuals than in the able-bodied population.

Participation in regular exercise has been investigated as a way to decrease both cardiovascular risk and depressive symptoms in able-bodied individuals, however a relatively small number of similar investigations have been performed in individuals with SCI. The current study examined the effects of a training protocol that incorporated arm ergomety and resistance training, two relatively inexpensive and accessible exercise modalities, on blood lipid variables (high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), total cholesterol (TC), triglycerides (TG) and HDL/TC ratio), fasting blood glucose (FBG) and psychological well being (PWB).

Baseline blood measures were obtained via fingerstick, and were subjected to automated analysis (Cholestech L.D.X, Cholestech, Hayward, CA). Resting systolic (SBP) and diastolic (DBP) were obtained via auscultation, while resting heart rate (HR) was obtained using either chest electrodes or an ear clip HR monitor. Three successively more difficult, 6-minute bouts of arm ergometry were performed, during which were monitored HR, arm rating of perceived exertion (ARPE) and total body rating of perceived exertion (TRPE). Systolic blood pressure and DBP were measured via auscultation immediately following each exercise session. Two minutes of rest were allowed between arm ergometry bouts. Psychological measures including the Center for Epidemiologic Studies depression scale (CES-D) (Radloff, 1977), an adaptation of Cantril's ladder of life satisfaction (Cantril, 1965), the

Perceived Stress Scale (PSS) (Cohen et al., 1983), a bodily pain question from the Short-Form 36-Item Health Survey (SF-36) (Ware and Sherbourne, 1992), the modified Exercise-Induced Feeling Inventory (EFI-C) (Rejeski et al., 1999) and perceived control questions from the Beliefs Scale (BS) (Shnek et al., 1997) were administered in interview format. One repetition maximum (1 RM) lifts were determined for chest press, shoulder flexion and elbow flexion.

Participants were matched on the basis of Coll ratings (Coll et al., 1998) and years post injury (+/- 10 years post) and then randomized to either exercise (EX) or control (C) groups. Subsequently EX participants took part in an exercise protocol that entailed the twice-weekly training of cardiovascular endurance and strength. During each exercise session, participants performed two bouts of arm ergometry and two resistance training exercises for shoulder musculature, elbow flexors, elbow extensors, chest musculature, wrist flexors, wrist extensors and back musculature, respectively. Duration of arm ergometry was adjusted according to individual participant tolerance, while work load was manipulated in order to attempt to elicit TRPE scores of approximately 3. Two sets of 15 repetitions of the resistance training exercises were performed during each of the first 6-8 sessions, in order to facilitate injury-free adjustment to resistance training. Subsequently, 3 sets of 10 repetitions were performed, with relatively heavier weights, in order to maximize improvements in strength. Control participants were asked to refrain from initiating a regular exercise program during the course of the study.

Post-testing occurred 3 months following the acquisition of baseline measures for the C group, and following the completion of between 22 to 24 exercise sessions for the EX group.

No significant changes in blood lipid variables, FBG or indices of PWB occurred during the course of the study. However, favourable baseline values for absolute blood data, FBG and PWB may have made improvements difficult. Improved arm ergometry tolerance was indicated in EX

participants by significant differences in percentage improvement of ARPE at the conclusion of the study. Statistically significant improvements in strength were not observed for the EX group, except in the case of left elbow flexion; however, trends were observed that suggested increased strength in the EX group in comparison with the C group following the completion of the experimental protocol.

Several recommendations are provided regarding the performance of future research examining the effects of arm ergometry and resistance training exercise on cardiovascular risk and PWB in individuals with SCI.

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"Education is not the filling of a bucket, but the lighting of a fire."
William Butler Yeats

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"Life is what happens when you are making other plans."
John Lennon

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Jenn, thanks for being my best friend. I can't wait to begin our life together.

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"Cha gheill! Cha gheill! Cha gheill!"

And finally, thanks to Queen's meds for providing me with a most inspirational new home.

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1.0 REVIEW OF LITERATURE AND STATEMENT OF PURPOSE

1.1 Spinal Cord Injury: Epidemiological Considerations

1.1.1 Incidence and Prevalence of Spinal Cord Injury

Owing to advancements in medical technology and improvements in clinical practices, rates of immediate and long-term survival from spinal cord injury (SCI) have improved steadily since World War II. Recently, a group of Canadian researchers estimated median survival time following SCI to be 38 years in those injured between the ages of 25 and 34 (McColl et al., 1997). Furthermore, between 1973 and 1986 alone, two-year survival following SCI in the United States increased by 66% (DeVivo et al., 1992). The annual incidence of SCI in Canada has been estimated to be approximately 64 in 100,000 people (Hu et al., 1996), and according to the model of Lasfargues et al.'s (1995), which was developed for the estimation of SCI prevalence in the United States, the prevalence of SCI in Canada is likely to increase markedly early in the new millennium. Of all spinal injuries, approximately 60% are experienced by young males between the ages of 16 and 30. Although many potential modes of injury exist for sustaining a SCI, the most common causes, in order of prevalence, are automobile accidents, falling, being hit by a falling object and sport-related accidents (Whiteneck et al., 1992). In the United States, individuals with SCI are divided fairly equally between paraplegia and quadriplegia, although at 52% of the SCI population, there are slightly more individuals with quadriplegia (Stover and Fine, 1987).

Mortality and Spinal Cord Injury 1.1.2

Mortality risk has been shown to be related to the level of SCI, such that individuals with

the highest-level spinal cord disruptions experience the highest mortality rates. In addition, mortality rates for individuals with SCIs have been positively linked to lesion severity, age at injury and earlier date of injury (Frankel et al., 1998). A great deal of research has been performed regarding cause of death following spinal cord injury. In a study of 888 patients conducted over 4 decades at the Centre for the Spinal Cord Injured in Hornbaek, Hartkopp et al. (1997) found the most common causes of death to be pneumonia and lung diseases, suicide and ischaemic heart disease. This study also identified heart disease, along with suicide, as one of the only two causes of death for which the standardized mortality ratio did not decrease over time. An examination of long-term survival in British SCI patients identified respiratory diseases, urinary diseases and heart disease respectively as the three most prevalent causes of death (Frankel et al. 1998). An earlier study of 1510 SCI patients conducted by Geisler et al. (1983) between 1973 and 1980 identified significant renal and neoplastic causes of death along with cardiovascular, respiratory and suicidal causes.

The consistency with which cardiac-related diseases have been identified as major causes of death for individuals with SCI in each of these studies, is matched only by respiratory diseases. In fact, research conducted by Cardus et al. (1992a) suggests that approximately half of SCI patients who live for 30 years after their injury and approximately one third of all SCI patients older than 65 die of cardiovascular causes. Similarly, Whiteneck and colleagues (1992) identified cardiovascular disease as the most prevalent cause of death after 30 years of living with a SCI, or among individuals with SCI who were over the age of 60. These findings are particularly disconcerting considering that, as a result of advancing medical technology, SCI patients are now living longer (Hartkopp et al., 1997) and, as a population, are becoming more

susceptible to diseases of aging such as cardiovascular disease. In a study of 77 SCI patients, Yekutiel et al. (1989) found that, although the incidence of ischaemic heart disease was higher in SCI patients compared to healthy, age-matched controls, the distribution of heart disease was unrelated to the level of spinal cord lesion. This finding suggests that all individuals with SCI, even those with low lesion levels, are at a greater risk of suffering from heart disease than are those who are not spinal cord injured. Furthermore, Bauman and colleagues (1994) detected silent ischemia during arm ergometry in 13 of 20 asymptomatic individuals with SCI. These results may indicate that many of those with SCI may also have cardiovascular disease and be completely unaware of their condition.

1.2 Cardiovascular Manifestations of Spinal Cord Injury

The autonomic nervous system plays an important role in the regulation of cardiovascular variables ranging from heart rate and myocardial contractility to vasomotor activation. This role is often compromised after suffering a SCI since lesions to the spinal cord can prevent both afferent and efferent action potentials from being transmitted along the lengths of neuronal axons.

1.2.1 The Heart

Parasympathetic innervation to the heart is from the vagus nerve, a cranial nerve, while the sympathetic innervation to the heart is from T4-T6 (Hopman et al, 1993; Phillips, et al., 1998). Consequently, SCI patients with lesions above T4 are able to decelerate, but experience difficulty accelerating their heart rate in response to physiological stimuli. For example, in a study by Erksson and colleagues (1988), maximal heart rates were 118 beats per

minute (BPM) for untrained individuals with quadriplegia, 119 BPM for trained individuals with quadriplegia and 138 BPM for those with incomplete quadriplegia, while analogously categorized individuals with paraplegia had mean maximal heart rates over 180 BPM. Similar results were observed by Drory and colleagues (1990), in their examination of physiological responses to arm crank ergometry in those with SCI. Research conducted by Thomas et al. (1997) demonstrates that the cardioacceleratory influence of group III and IV afferent fibres is absent below the level of the spinal cord lesion in individuals with SCI. In addition, as a result of lower limb venous pooling and low right ventricular filling pressure due to the absence of lower limb vascular tone, individuals with SCI have lower stroke volumes and higher resting heart rates than do non spinal cord injured individuals (Hopman et al., 1992). Each of the aformentioned traits has important implications regarding the ability of the heart to respond appropriately to exercise stimuli. In individuals with cardiovascular disorders, it is also important to note that lesions at or above the T4 level make the transmission of cardiogenic pain impossible, potentially allowing myocardial ischaemia to occur unnoticed during periods of exertion by a patient.

1.2.2 Vasomotor Control

Sympathetic control of the peripheral vasculature is maintained, in those without SCI, via neurons emerging from spinal cord roots T1 to L1-L2 (Guyton, 1991). Vasomotor adjustments to postural changes or changes in activity are not possible in the denervated area for individuals with SCI (Frewin et al., 1973), resulting in increased potential for visceral and peripheral pooling of blood and the associated occurrence of low blood pressure and orthostatic hypotension in some patients (Blackmer, 1997; Teasell et al., 2000). However, Johnson and colleagues (1971)

reported that those with lesions below the mid thoracic level, T6, rarely suffer from this condition. Similarly, Drory and colleagues (1990) observed significantly lower systolic and diastolic blood pressures in individuals with cervical injuries in comparison with those with thoracic and lumbar injuries, both at rest and during the performance of submaximal arm ergometry.

The research of Johnson and colleagues suggested that individuals with paraplegia help to counteract the effects of lost vasomotor control through plasma volume expansion facilitated by increased activity of the renin-angiotensin system and associated elevations in plasma concentrations of aldosterone. This proposed mechanism of long-term blood pressure control continues to be supported, although it is now thought that spinal reflexes may also contribute to the maintenance of blood pressure in those with SCI (Blackmer, 1997).

Orthostatic hypotension is commonly treated via progressive increases in sitting angle, the donning of anti-embolic, elastic stockings and an abdominal binder and also by consuming a high salt diet (Blackmer, 1997). If these interventions are insufficient, pharmaceuticals such as ephedrine, pseudoephedrine, fludrocortisone, ergotamine, metoclopramadine, clonidine and midodrine may be taken to further incur increases in blood pressure (Blackmer, 1997).

1.2.3 Autonomic Dysreflexia

T6 is the level at which the major splanchnic outflow begins (Ashley et al., 1993). Patients with injuries at or above this level are prone to autonomic dysreflexia (AD), a condition in which afferent stimulation of the spinal cord by intact infralesional sensory nerves results in the elicitation of a severe hypertensive response (Ashley et al., 1993; Karlsson, 1999; Teasell et

al., 2000). Autonomic dysreflexia can be triggered by such commonly experienced stimuli as bladder or bowel distension, menstruation, or any painful stimulus below the level of the spinal cord lesion (Phillips et al., 1998), and thus can be a common and dangerous problem for some individuals with SCI. Episodes of AD tend to be more severe in individuals with neurologically complete lesions (Karlsson, 1999).

In addition to high blood pressure, symptoms of AD may include severe headache, cutis anserina, paresthesias, shivering, flushing and sweating above the level of the injury, obstructed nasal passages, desire to void, anxiety, malaise and nausea (Karlsson, 1999). Although baroreceptor-mediated bradycardia is considered to be a common physiological reaction to hypertension during episodes of AD (Mathias, 1991; Phillips et al., 1998), it should not be expected to occur in all cases (Kewalramani, 1980).

The hypertension elicited by infralesional stimulation of the spinal cord in individuals with AD has been considered, in the past, to occur simply as a result of uninhibited reflex sympathetic outflow from the spinal cord, which caused severe vasoconstriction (Mathias, 1991). Recent research has identified several other potential mechanisms for the occurrence of AD including augmented neurotransmitter release per stimulus, remodeling of spinal preganglionic neurons below the level of SCI and increased numbers or sensitivity of alpha adrenergic receptors in the peripheral vasculature (Mathias, 1991; Karlsson, 1999; Teasell, 2000).

AD is typically treated via the removal or minimization of any stimulus that brings on the reaction, particularly bladder distention. Pharmaceuticals such as phenoxybenzamine and nifedipine may also be used to combat AD (Karlsson, 1999).

1.3 Cardiovascular Risk in Individuals With Spinal Cord Injury

Current standardized mortality rates indicate that individuals with SCI are twice as likely to suffer from nonischaemic heart disease and 1.4 times as likely to suffer from ischaemic heart disease than are able-bodied individuals (Phillips et al., 1998). The American College of Sports Medicine (ACSM, 1993) has identified several risk factors for the development of coronary heart disease (CHD) including serum lipid levels, smoking, hypertension, physical inactivity, obesity, diabetes and glucose intolerance, psychosocial stress and family history (ACSM, 1993). Based on these risk factors, particularly serum lipids, hypertension, physical activity, obesity, diabetes and psychosocial stress, evidence exists to explain why individuals with paraplegia are at a higher risk than non-spinal cord injured individuals for developing CHD.

1.3.1 Serum Lipid Levels

1.3.1.1 High-Density Lipoprotein Cholesterol

Of all serum lipid components, high-density lipoprotein cholesterol (HDL) has received the most attention in the SCI literature. Serum levels of HDL generally have been found to be lower than normal in individuals with SCI (Vaziri et al., 1982; Brenes et al., 1986; Bauman et al., 1992; Krum et al., 1992; Shetty et al,. 1992; Zlotolow et al., 1992; Maki et al., 1995; Washburn and Figoni, 1999). In an examination of HDL cholesterol levels between individuals with a spectrum of activity levels, LaPorte et al., (1983) reported a mean HDL-C level of only 27 mg/dl for SCI patients. This corresponded to 90% and 350% greater risks of heart attack for SCI patients versus controls and marathon runners respectively. A more recent study of 541 SCI patients in the United States demonstrated inverse relationships between lesion level and mean

serum HDL content as well as between completeness of lesion and mean serum HDL content (Bauman et al., 1998). Apstein and George (1998) also found serum lipid concentration to be related to injury level, in addition to duration of injury, in the first year following SCI in 100 patients. In contrast, although Bauman et al. (1992) found depressed mean serum HDL levels in 100 veterans with SCI in comparison with controls, no significant relationship was observed between lesion level and HDL status.

Unlike the previous authors, Janssen and colleagues (1997) did not observe significant differences in HDL levels between those with SCI and able-bodied individuals, although the significance of their findings may have been influenced by the small sample size (n=37) and the young mean age of the participants (37.4 ± 12.0 years) involved in their study. Rather than SCI, the authors identified modifiable risk factors including physical activity, smoking, alcohol consumption and obesity as the most important determinants of serum lipid levels. Alcohol consumption was the most reliable predictor of HDL level in SCI patients in this particular study. HDL level and alcohol consumption were found to be positively related. Cardus and colleagues (1992) also found no difference with respect to HDL levels between those with SCI and able-bodied individuals, although they used national data from the United States, rather than able-bodied controls, for the purposes of comparison.

Normally active individuals with paraplegia tend to have low HDL levels in comparison with able-bodied controls, however national caliber wheelchair athletes with SCI have been shown to have HDL levels similar to those of the able-bodied population (Brenes et al., 1986; Dearwater et al., 1986). Although this finding suggests that exercise may be an important determinant of HDL levels in SCI patients, recent work by Apstein and George (1998) suggests

that it may not be as important as previously thought. They postulate that the simple interruption of the autonomic nervous system in SCI patients adversely influences lipid metabolism since only 44% of the decrease in HDL level they observed in patients during the first year following SCI could be associated with patterns of physical activity. This theory is supported by their finding that patients with lesion levels below T10, one of the lowest levels of sympathetic outflow, did not experience the decreases in serum HDL levels observed in patients with higher lesions during the first year following SCI. Nevertheless, Dallmeijer and colleagues (1999) found participation in physical activity to be the greatest determinant of improvement in HDL status during the first two years following spinal injury. Involvement in regular physical activity may potentially improve HDL levels in those with SCI via improvements in body composition, insulin sensitivity and metabolic changes associated with physical fitness (Washburn and Figoni, 1999).

1.3.1.2. Low-Density Lipoprotein Cholesterol

In contrast to HDL levels, low-density lipoprotein cholesterol (LDL) levels in individuals with SCI tend to be similar to those seen in by able-bodied individuals (Bauman et al., 1992; Cardus et al., 1992; Zlotolow et al., 1992; Bauman et al., 1999b). However, since those with SCI are at a higher than normal risk for developing cardiovascular diseases, their ideal LDL values may actually be lower than those of the general population (Bauman et al., 1999b).

1.3.1.3 Total Cholesterol

Total cholesterol (TC) has been found by some researchers to be lower in those with SCI than it is in the general population (Bauman et al., 1992; Shetty et al., 1992), however Zlotolow and colleagues (1992) did not find a significant difference between the two populations. A

recent review of literature identified TC as being lower than normal in those with SCI in most studies, including those in which the difference failed to reach significance (Washburn and Figoni, 1999). Perhaps more important than TC is the TC/HDL ratio, which has been identified as an independent predictor of cardiovascular risk (Stampfer et al., 1991). TC/HDL ratio was found to be elevated in 57% of individuals with SCI in one study (Maki et al., 1992), however other authors (Bauman et al., 1992; Janssen et al., 1997) observed no difference in TC/HDL ratios between those with SCI and able-bodied individuals.

1.3.1.4 Triglycerides

Studies examining triglycerides (TG) in those with SCI have yielded inconsistent results. Vaziri and colleagues (1982) observed elevated TG levels, however the participants in their study suffered from renal complications that were shown to influence other lipid variables, particularly HDL levels. In contrast, others have failed to detect significant elevations in TG in those with SCI in comparison with controls (Washburn and Figoni, 1999).

Overall, research indicates that individuals with SCI commonly exhibit serum lipid profiles that place them at an increased risk of suffering from cardiovascular diseases. Consistent findings of low HDL levels are a particular concern for the SCI population, despite the possibility that they may be accompanied by low TC. Additional research is necessary to confirm the specific relationships between SCI and lipid variables such as TC/HDL ratios and TG levels.

1.3.2 Diabetes and Glucose Tolerance

Disorders of carbohydrate metabolism are commonly observed in individuals with SCI

(Bauman and Spungen, 2000), and seem to occur at younger than normally expected ages in this population (Bauman and Spungen, 1994). Impaired glucose tolerance has been positively associated with both lesion level and body fat percentage (Bauman et al., 1999a). In an examination of veterans, 82% of able-bodied controls had normal oral glucose tolerance, while only 50% of those with SCI tolerated oral administrations of glucose normally (Bauman and Spungen,1994). In support of earlier research by Duckworth et al. (1980), the same study found that SCI veterans had higher mean glucose and insulin values during oral glucose tolerance tests in comparison with controls, indicating decreased insulin sensitivity. Karlsoon (1999) also noted impaired insulin sensitivity in a group of seven individuals with high SCI, however, unlike the previous authors, he observed normal glucose tolerance in his group of participants. Increased insulin resistance following SCI may potentially be attributed to a number of factors including decreases in overall skeletal muscle mass, proliferation of type IIb muscle fibres in paralyzed skeletal muscle, decreases in physical activity and increases in adiposity (Bauman et al., 1999b). Proliferation of type IIb fibres may contribute to increased insulin resistance since they are not as responsive to insulin as oxidative muscle fibres.

In addition to the abnormal responses to glucose administration observed by the previous authors, significantly lower fasting blood glucose levels have been detected in individuals with SCI in comparison with able-bodied individuals, independent of activity level (Dearwater et al., 1986) and glucose tolerance (Bauman and Spungen, 1994). This finding may be indicative of decreased hepatic glucose output in those with SCI.

1.3.3 Hypertension

Frankel and colleagues (1972) reported the existence of an inverse linear relationship between mean diastolic blood pressure and lesion level, with the highest diastolic blood pressures occurring in individuals with the lowest spinal cord lesions. As discussed previously, most vasomotor control is lost below the level of spinal lesion in individuals with SCI, leading to decreased peripheral resistance and increased potential for the occurrence of hypotension and orthostatic intolerance. Despite this change, pathologically high blood pressures have been reported in some patients with SCI (Frankel et al., 1972, Yekutiel et al., 1989), and may occur as a result of renal complications associated with spinal injury (Frankel et al., 1972). Yekutiel and colleagues (1989) found that 34% of the 77 SCI patients they studied suffered from hypertension, compared to only 18.6% of age-matched controls. Nevertheless, cardiovascular risk due to hypertension is commonly determined to be low in individuals with SCI (Krum et al., 1992)

1.3.4 Physical Inactivity

As a result of their respective injuries, individuals with SCI tend to be largely sedentary (Dearwater et al., 1986). Most ADL require between only 15 and 24% of heart rate reserve (Hjeltnes and Vokac, 1979), and therefore are not usually sufficient to elicit training effects or maintain cardiovascular fitness. In one study, the only activities that experimental participants participated in that were identified as stressful enough to elicit training effects were ambulating with crutches, propelling a wheelchair uphill, playing wheelchair basketball and performing rehabilitative arm ergometry (Hjeltnes and Vokac, 1979). As a consequence, maximal aerobic power is much lower, on average, in those with SCI than it is in able bodied individuals;

occasionally so low as to inhibit independent living (Noreau and Shephard, 1995).

Unfortunately, the loss of lower limb motor control can lead to a debilitating cycle in which a decreased incentive to exercise leads to decreased activity which leads to decreased capacity to complete physical work which then results in a further decrease in incentive to exercise (Hoffman, 1986). In a comparison of leisure activity profiles between those with SCI and non-disabled individuals, Kennedy and Smith (1990) observed that, although the individuals with SCI had been more physically active than the non-disabled individuals prior to becoming injured, they expressed reduced expectations with respect to future involvement in physically active leisure activities in comparison with the non-disabled individuals.

1.3.5 Obesity

Mollinger et al. (1985) have shown that daily energy expenditure and basal metabolic rate for SCI patients are correlated with lesion level such that higher lesion levels result in lower daily energy expenditures and basal metabolic rates. Resting metabolic rates have been shown to be lower than normally predicted in individuals with thoracic SCI (Sedlock and Laventure, 1990). Since resting metabolism accounts for the major component of daily energy expenditure, those with SCI may be more likely than able-bodied individuals to become obese. This concept is supported by the work of several researchers who have each noted increased amounts of adipose tissue in individuals with SCI in comparison with those from the general population (Janssen et al., 1997; Karlsson, 1999; Kocina, 1997; Sedlock and Laventure, 1990). Twenty-seven percent of men with SCI studied by Janssen et al. (1997) were classifiable as Grade I obese, while the average sedentary adult with SCI observed by Kocina (1997) had a sufficient amount of body fat

to be at increased risk of cardiovascular disease. Furthermore, sedentary, wheelchair-bound paraplegics have been shown to be significantly more obese than sedentary, able-bodied individuals (Zwiren and Bar-Or, 1975).

1.3.6 Psychosocial Stress

The high amount of psychosocial stress associated with SCI is indicated by the prevalence of suicide amongst individuals with SCI. Numerous longitudinal studies have cited suicide as one of the most common causes of death amongst SCI patients, particularly those with paraplegia (Frankel et al., 1998; Geisler et al., 1983; Hartkopp et al., 1997). The psychological aspects of SCI, as they pertain to life quality, are the focus of the following segment of this literature review.

1.4 Quality of Life

1.4.1 Quality of Life in Individuals With SCI

A large number of studies addressing quality of life (QOL), also referred to as life satisfaction (LS) or subjective well-being (SWB), in individuals with SCI exist in the literature. These studies often examine dimensions of health related quality of life (HRQL), however, they also commonly consider the impact of objective variables which cannot be directly influenced by health status such as income, living arrangements, type of employment, social support and marital status, amongst others. Studies that evaluate QOL cannot always be considered as direct analogs to those that evaluate HRQL, however their findings remain clinically relevant. For example, QOL has been identified by some researchers as a significant predictor of mortality following SCI (Krause and Kjorsvig, 1992; Krause et al., 1997). In one study, QOL was a better

predictor of four-year post-injury survival than was recent medical history (Krause and Kjorsvig, 1992).

1.4.1.1 Demographics of Life Satisfaction in Individuals With SCI

Studies that have examined QOL in individuals with SCI have generally found it to be lower than it is in the general population (Westgren and Levi, 1998; Post et al., 1998; Fuhrer et al., 1992; McColl et al., 1999). In particular, research indicates that individuals with SCI are less satisfied than individuals from the general population with variables such as self-care ability, vocational situation, finances, leisure activities and sexual activity (Post et al., 1998; Fuhrer et al., 1992). In contrast, some authors have reported no differences in QOL between able-bodied individuals and those with SCI (Siosteen et al., 1990; Whiteneck et al., 1992). Cushman and Hassett (1992) conducted a study in which most individuals with SCI subjectively rated their quality of life as being as good, or even superior to, that experienced by age-matched peers. This discrepancy may be due, in part, to inconsistencies between researchers with respect to the variables used to determine QOL. Components of QOL such as family relationships, housing and daily living tasks have been associated with high levels of satisfaction in those with SCI (Fuhrer et al., 1992; Post et al., 1998).

1.4.1.2 Factors Influencing Quality of Life in Individuals With SCI

A great deal of research has been performed in order to identify factors that are important determinants of QOL in those with spinal cord injury. Although a small number of studies have found neurological status, or injury level to be correlated to QOL (Dijkers, 1999; Evans et al., 1993) most researchers have found little or no relationship between neurological impairment and QOL following SCI (Siosteen et al., 1990; Cushman and Hassett, 1992; Fuhrer et al., 1992;

Whiteneck et al., 1992; Post et al., 1998a; Vogel et al., 1998; Westgren and Levi, 1998; Manns and Chad, 1999). Rather, the best predictor of QOL seems to be the patient's self-reported ability to fulfill desired roles such as living independently (Fuhrer et al., 1992). This research supports the usage of subjective patient perceptions, rather than objective measures of function, in the determination of QOL.

There is disagreement in the literature regarding the effects of aging and duration of injury on QOL, with some studies demonstrating negative effects (Krause and Crewe, 1990; Eisenberg and Saltz, 1991; Whiteneck et al., 1992; Stensman, 1994; Krause, 1997; McColl et al., 1999), others indicating positive effects (Gerhart et al., 1993; Westgren and Levi, 1998), and yet others indicating no effects (Fuhrer et al., 1992; Post et al., 1998b; Vogel et al., 1998; Dijkers, 1999). However, negative effects of aging on QOL have been shown to occur when aging is accompanied with increased dependence on others in order to perform ADL (Gerhart et al., 1993; McColl et al., 1999).

Several studies advocate the existence of a positive relationship between social integration and improved QOL in those with SCI (Siosteen et al., 1990; Fuhrer et al., 1992; Post et al., 1998a; Vogel et al., 1998). Anson (1993) noted higher reported QOL in individuals who felt that they contributed positively to their respective communities, despite being injured. Increased QOL has also been observed in those who were able to secure employment following SCI (Fuhrer et al., 1992; Westgren and Levi, 1998; Vogel et al., 1998; McColl et al., 1999; Richards et al., 1999), although one study (Cushman and Hassett, 1992) could not support this observation. Together, these findings are indicative of the importance placed by those with SCI on the ability to fulfill normal social roles.

Social support has also been suggested as an important determinant of QOL following SCI. Community support in the form of accessibility to educational and recreational facilities, employment, transportation services has been associated positively with QOL (Siosteen et al., 1990; Anson et al., 1993). In addition, those who are married have been shown in several studies to experience higher QOL (Post et al., 1998b; Westgren and Levi, 1998; McColl et al., 1999), although Fuhrer et al., (1992) found no relationship between marital status and QOL.

Not surprisingly, perceptions of health status and the presence of medical complications secondary to SCI have consistently been shown to be negatively associated with QOL (Fuhrer et al., 1992; Stensman, 1994; Rintala et al., 1998; Vogel et al., 1998; Westgren and Levi, 1998; Richards et al., 1999). In contrast, issues of mobility and access to one's environment, such as ability to drive an automobile, have been positively associated with QOL on a consistent basis (Siosteen et al., 1990; Fuhrer et al., 1992; Richards et al., 1999).

It has been proposed that gender may also play a role in the determination of QOL following SCI because of differing value systems between men and women (Krause, 1998). This proposal has been supported by Dijkers (1999) who observed higher self-reported life satisfaction in women with SCI than in men. However, in another study, Post and colleagues (1998) failed to observe differences in QOL between men and women with SCI.

Stensman (1994) noted decreased QOL amongst individuals who felt that they were blameless for their injuries. Those who were injured in accidents that could be attributed to their own actions seemed better able to accept the consequences of their injuries. This finding is consistent with the research of Fuhrer and colleagues (1992), who identified perceived control

over one's life circumstances as a contributing factor in the determination of QOL in individuals with SCI.

1.4.2 The Construct of Health Related Quality of Life

Traditional clinical assessments of quality of life (QOL) have involved comparing objective indices of an individual's actual traits and abilities against standards designated by clinicians as being definitive of good QOL (Eisenberg and Saltz, 1991). Although simple and consistent in their administration, these assessments have disregarded the individual values and needs of patients, thus preventing the evaluation of QOL as it has been perceived by patients. Failure to address individuals' perceptions has represented a significant methodological oversight, since interpersonal differences in values and expectations make QOL a construct that cannot be defined identically for all individuals. In recent years, researchers have begun to address this oversight through the development of individualized QOL evaluations.

The construct of health related quality of life (HRQL) is a subcomponent of QOL that addresses personal attributes specifically related to health status which are valued by individuals, such as well-being, physical, emotional and intellectual function as well as roles in the family, the workplace and the community (Wenger and Furberg,1990). Unlike QOL, HRQL is unaffected by non-health related variables such as socioeconomic and employment status. An individual's objectively-determined performance on a particular functional task does not always provide an accurate indication of his or her perceived QOL (Patrick et al., 1988), since one's perceived abilities may be incongruent with one's actual abilities. Accordingly, assessment of HRQL involves the subjective determination of a particular individual's perceived abilities and

his or her level of satisfaction with those perceived abilities (Rejeski et al., 1996). The value placed by an individual on each area of function being assessed is a central aspect of HRQL assessment (Rejeski et al., 1996). A patient with low perceived competence in an area of function to which he or she ascribes little value does not necessarily experience low HRQL. Consequently, in order to accurately assess HRQL, one must primarily consider the differences that exist between an individual's aspirations and their abilities and accomplishments (Dijkers, 1997). In adherence to this principle, determinants of HRQL may be weighted quite differently between individuals.

HRQL encompasses several dimensions, the identification of which varies slightly between authors. For example, Shumaker and colleagues (1990) identify physical functioning, emotional well-being, social functioning, role activities, life satisfaction and health perceptions as the dimensions of HRQL. Alternatively, Rejeski et. al(1996) have identified global indices of HRQL, physical functioning, physical symptoms, psychological well being, social functioning and cognitive functioning as the core dimensions of HRQL. Physical functioning addresses the performance of ADLs as well as self-perceptions of physical ability and health, while issues such as arousal, somatic sensations and sleep patterns lie in the domain of physical symptoms. Depression, anxiety, affect and self esteem are primary components of emotional well being, while fulfillment of societal roles and leisure activities are addressed by the social function dimension of HRQL. Finally, cognitive function has to do with problem solving ability, memory and attention.

1.5 Depression

1.5.1 Manifestations of Depression

Although every dimension of HRQL is clinically relevant, a great deal of the research regarding HRQL in individuals with SCI has had to do with the dimension of psychological well being (PWB). Depression and negative mood are of particular concern to clinicians dealing with patients who have sustained an SCI because of the undesirable effects that they may have on many aspects of everyday living such as eating habits, sleep patterns, psychomotor performance, energy level, and ability to concentrate (American Psychiatric Association, 1987). That depressed individuals have been found to experience longer inpatient rehabilitation periods (Malec and Neimeyer, 1983), suggests that depression may interfere with conventional medical treatment following SCI. In addition, compared to persons from the general population, depressed individuals with SCI engage more in harmful behaviours such as suicide (Charlifue and Gerhart, 1991), excessive risk taking including substance abuse (Krause et al., 1997), and self-neglect (Malec and Neimeyer, 1983; Macdonald et al., 1987). Two distinct studies identified the rate of suicide in individuals with SCI to be five times the rate observed in the able-bodied population (DeVivo et al., 1991; Hartkopp et al., 1998). Those who are depressed also tend to induce agitation, and hostility in hospital rehabilitation staff (Frank et al., 1986), and be actively avoided in everyday social environments (Coyne, 1976), potentially affecting the social functioning dimension of HRQL. In this manner, depression and negative mood may actually be self-perpetuating.

1.5.2 Depression defined

The American Psychological Association (1987), defines a major depressive episode as a change from previous functioning which manifests itself in the experience of depressed mood or loss of interest in pleasure in most activities, as well as associated symptoms, for at least two weeks. At least five associated symptoms including: (1) significant weight loss or gain without dieting, or daily decreases in appetite; (2) insomnia or hypersomnia; (3) psychomotor agitation or retardation; (4) fatigue or low energy level; (5) feelings of worthlessness or guilt; (6) diminished ability to concentrate or indecisiveness; (7) thoughts of death or suicide, must be experienced by an individual before he or she can be considered to be clinically depressed.

Depression that is not severe enough to meet the above criteria, is known as nonclinical depression, or negative mood. Nonclinical depression is experienced by most individuals on occasion, and typically results from identifiable environmental stressors such as grief or personal loss (Leith, 1994). Although this type of depression may significantly affect an individual's HRQL, it must not be confused with, or referred to as, clinical depression, which may be either reactive or endogenous (Leith, 1994).

1.5.3 Depression following SCI

Depression has been viewed by some as an essential step in the recovery process following the sustenance of a SCI. Stage models of SCI recovery (Hohmann, 1975; Stewart, 1977; French and Phillips, 1991) identify depression as one of several narrowly-defined psychological stages which each patient must pass through prior to being eligible to be considered to have recovered from their injury. A typical example of such a sequence, as

proposed by Hohmann (1975), is denial, depression, internalized hostility, externalized hostility and reaction against independence. Proponents of stage theories assume that the passage of time eventually drives each patient out of the depressive stage of their psychological recovery. In addition, they assume that the injury itself, rather than the injured person's personality characteristics, is the primary factor which influences behaviour following SCI (Frank et al., 1987)

Recently, stage theories have received criticism for being based largely on anecdotal reports. Little, if any, empirical evidence exists to support the notion that depression is an inevitable stage of psychological recovery following SCI (Frank et al., 1987). Although Richards (1986) noted decreases in SCI patients' depression over a one-year period following their respective injuries, most authors have failed to establish a link between time post-injury and depression status (Cushman and Dijkers, 1991; Craig et al., 1994; Scivoletto et al., 1997). Judd and colleagues (1989) found that while 20% of individuals with SCI experienced persistent depression during rehabilitation following SCI, the majority of individuals were either undepressed or were only subject to isolated episodes of dysphoria brought about by transient situational factors. Other estimates of the prevalence of depression in those with SCI have ranged between approximately 20 to 45% (MacDonald et al., 1987; Craig et al, 1994; Boekamp et al., 1996; Scivoletto et al., 1997). These estimates are higher than those made for the general population (Fuhrer et al., 1993; Murphy et al., 2000), but are congruent with the 20% rate of clinical depression observed by primary care practitioners dealing with outpatients (Zung et al., 1993). In contrast, Cushman and Dijkers (1991) observed comparable levels of depression between those in SCI rehabilitation and a control group of hospital visitors.

Overall, these findings suggest that depression may be more common in those with SCI than it is in individuals in the general population, but that it is not an inevitable consequence of spinal injury. Some authors have identified abnormal secretion of catecholamines, which play a role in the modulation of affect, as a potential physiological mechanism which may account for the elevated prevalence of depression observed in those with SCI (Frank et al., 1987; Boekamp et al., 1996). Presently, however, this proposal remains to be validated.

1.5.4 Variables Influencing the Development of Depression In Those With SCI

A great deal of the research that has been performed regarding depression in individuals with SCI has focused on establishing relationships between various personal characteristics and depression status. Most of these studies have failed to relate objective measures of neurological impairment with the development of depression (Richards, 1986; Judd et al., 1989; Cushman and Dijkers, 1991; Fuhrer et al., 1993). In contrast, MacDonald and colleagues (1987) observed that 86% of those with SCI whom they examined and determined to be depressed were quadriplegic, suggesting the possible existence of a link between lesion level and likelihood of becoming depressed. Other researchers have suggested that handicaps, defined as disadvantages arising from SCI that limit or prevent fulfillment of a desired role (Richards et al., 1999), contribute more to the development of depression than does the degree of neurological impairment experienced by an individual (Tate et al., 1994). Handicaps in social integration, for example, have been linked to increased depression in individuals with SCI (Fuhrer et al., 1993; Tate et al., 1994). Autonomy (Tate et al., 1994; Scivoletto et al., 1997), and factors contributing to autonomy such as financial status (Tate et al., 1994), employment (Fuhrer et al., 1993), physical

independence (Tate et al., 1994), education (Zung, 1993; Scivoletto et al., 1997) and mobility (Fuhrer et al., 1993) have been negatively associated with depression in individuals with SCI on a consistent basis. In addition, several authors have noted increased rates of depression amongst women with SCI in comparison with their male counterparts (Fuhrer et al., 1993; Zung, 1993; Murphy et al., 2000), although Richards (1996) found no relationship between sex and depression status. Advancing age has been inconsistently linked with increased depression (Fuhrer et al., 1993; Zung, 1993; Charlifue et al., 1999), but this relationship may simply be a reflection of the positive relationship between medical complications and depression that has been noted in those with SCI (Cairns et al., 1996; Scivoletto et al., 1997; Rintala et al., 1998). Finally, Elliot and Frank (1996) established links between pre-injury psychological disorders, alcohol and substance abuse and post-SCI depression, highlighting the potential importance of individual personality characteristics and behaviours in the development of psychological outlook following SCI.

1.5.5 Interventions That Have Been Used to Combat Depression in SCI

Clinical depression in those with SCI has been treated via conventional means such as participation in psychotherapy and consumption of antidepressant medications (Judd et al., 1989). These treatments have been shown to reduce depressive symptoms in individuals with SCI (Judd et al., 1989).

Enrollment in cognitive behaviour therapy to improve coping skills following SCI may also assist in the reduction of depression, since problem solving skills and perceived competence in problem solving has been linked to decreased depression in individuals with SCI (Elliott et al.,

1991). King and colleagues (1999) noted significant differences in depression and anxiety between a control group and a group of individuals who underwent seven sessions of coping effectiveness training following SCI. Improved affect was noticed by 79% of the individuals who underwent the coping effectiveness training. Alternatively, in a study conducted by Craig and colleagues (1998), long-term training to improve coping skills was only effective in individuals who were highly depressed (Craig et al., 1998) prior to initiating therapy.

Several authors have examined the effects of participation in physical activity on depression in those with SCI, however their collective findings have been inconclusive. Jacobs and colleagues. (1990) observed decreased amounts of depression in wheelchair athletes in cross-sectional comparison with non-athletes with SCI, however Foreman et al. (1997) found no difference in psychological profile between sport participants and non-participants with SCI. Similarly, three studies (Alexander and Sipski, 1990; Guest et al., 1997; Klose and colleagues, 1997) elicited decreases in indices of depression in experimental participants with SCI using functional electrical stimulation (FES) training programs, however another author (Bradley, 1994) increased negative, rather than positive, affect in participants following a FES training program. In this particular case, increased negative affect came about as the result of unrealistic expectations that had been developed by experimental participants.

1.6 Exercise and Depression

1.6.1 Cross-Sectional Relationships Between Exercise Participation and Depression

Several researchers have examined cross-sectional relationships between physical activity and depression status. In a secondary analysis of four cross-sectional surveys conducted on

separate population samples over a 10-year period in both Canada and the United States, Stephens (1988) established a strong negative relationship between level of physical activity and depression status. This relationship existed despite the fact that each survey implemented distinct measures of involvement in physical activity and psychological status. Other studies have supported Stephens' (1988) findings (Thirlaway and Benton, 1992; Steptoe et al., 1997), however de Geus and colleagues (1993) found no cross-sectional relationship between aerobic fitness and psychological status.

1.6.2 Effects of Participation in Exercise in the Clinically Depressed

Some clinicians have implemented exercise as a form of treatment for clinical depression. Numerous studies have elicited decreases in depressive symptoms in clinically depressed individuals following participation in a program of regular exercise (Greist et al., 1979; Martinsen, 1985; Martinsen, 1989). The psychological benefits of exercise have been suggested to be comparable to those obtained through participation in traditional psychotherapy (Greist et al., 1979; Raglin, 1999). However, those treated with exercise may actually be less likely to experience relapses of depression than those treated with psychotherapy (Greist et al., 1979). In one study, patients collectively ranked exercise participation as the most important element of the comprehensive therapy they had received for clinical depression (Martinsen, 1990). Thus, in the clinically depressed population, exercise appears to be an effective means of decreasing depressive symptoms.

1.6.3 Exercise and Depression in Healthy Populations

Investigations of the effects of exercise on depressive symptoms in populations of healthy individuals have yielded less consistent results. One explanation for this inconsistency is that participation in an exercise program may not be capable of improving mental health status of an individual unless he or she is experiencing elevated levels of anxiety or depression (Raglin, 1990). If this is the case, then those who are not depressed may benefit from exercise mainly through prevention of depression, rather than from improvement of psychological status. This concept is supported by the work of several authors (Blumenthal et al., 1982; Hughes et al., 1986; Blumenthal et al., 1989; Cramer et al., 1991; de Geus et al., 1993; King et al., 1993). Conversely, others have successfully elicited significant improvements in affect though participation in exercise (Moses et al., 1989; McMurdo and Burnett, 1992; Browne et al., 1995). In a review of studies examining the effects of exercise on depression, Byrne and Byrne (1993) found that exercise improved depression status or negative mood in all studies whose participants were healthy adults. Similarly, Steinberg and colleagues (1997) observed significant improvements in mood in healthy individuals following single bouts of aerobic exercise.

1.6.4 Exercise and Depression In Clinical Populations

Exercise has been implemented, with variable success, to decrease depressive symptoms in individuals suffering from medical conditions other than clinical depression. In a study involving individuals with chronic obstructive pulmonary disease, those randomized to a condition incorporating exercise in addition to stress management and education experienced improvements in depressive symptoms after 10 weeks in comparison with those who participated

only in education and stress management or a control condition (Emery et al., 1998). Similar effects were noted in a sample of patients following myocardial infarction (Taylor et al., 1986). Conversely, Stern and Cleary (1982) found no differences in psychosocial parameters between post myocardial infarction patients who had either been in a control group, or who had participated in two years of a supervised exercise program. Another group of researchers (Kugler et al., 1994) found that exercise rehabilitation for cardiac patients was not as effective at decreasing depression as psychotherapy. More research is needed in order to determine the specific effects of exercise on affect in individuals from clinical populations.

1.6.5 The Importance of Exercise Program Specifications

Inconsistency in the results of studies examining the effects of exercise on depression in non-clinically depressed individuals may be partially due to differences in the exercise protocols employed by researchers. Several components of an exercise program may be manipulated in order to potentially influence psychological effects.

The social aspect of exercise has been identified as one such component (Paluska and Schwenk, 2000). Hughes and colleagues (1986) demonstrated that 12 weeks of nonsocial exercise was insufficient to improve psychological parameters in previously sedentary men. Conversely, another group of researchers (King et al., 1993) elicited improvements in depression in those who participated in home exercise programs in comparison with those in a control group. Therefore, a social element may not always be necessary in order to incur positive changes in depression status through exercise.

Several authors have examined whether or not a change in fitness status is necessary in order to decrease depressive symptoms with exercise. Although one group of researchers noted a significant correlation between submaximal cardiorespiratory fitness and general well-being (Cramer et al., 1991) in individuals who took part in brisk walking training, most studies have failed to find a relationship between fitness and depressive status (Blumenthal et al., 1982; Martinsen et al., 1989; Steptoe et al., 1989; Martinsen, 1990;). In a cross-sectional study, Thirlaway and Benton (1992) found no relationship between aerobic fitness and positive mood, but did find a relationship between frequency of participation in physical activity and positive mood. Collectively, this research seems to indicate that participation in exercise may alone be sufficient to elicit changes in depression and that the exercise being performed does not have to be of a sufficient intensity to stimulate improvements in fitness. In further support of this concept, two studies failed to detect significant differences in changes in depression between individuals assigned to exercise programs of differing intensities (King et al., 1993; Worcester et al., 1993), while another study (Moses et al., 1989) elicited psychological benefits in those randomized to a moderate intensity aerobic exercise program, but not in those randomized to a high intensity aerobic exercise program.

Few authors have devoted attention to the influence of exercise program duration on psychological outcomes. In a literature review, North and colleagues (1990) observed maximal effect sizes for depression in training regimens lasting at least 17 weeks. Conversely, Kugler and colleagues (1994) performed a meta-analysis which found effect size of exercise programs in cardiac patients to be unrelated to duration. The exact nature of the relationship between

exercise program duration and improvements in psychological status due to participation in exercise remains to be determined.

Since preference varies between individuals in terms of the type of exercise each person enjoys, exercise type is a factor which could potentially influence the psychological effects of an exercise program. The majority of studies which have compared the psychological effects of participation between different forms of exercise, for example, aerobic versus resistance, have failed to detect significant differences (Taylor, 1986; Martinsen, 1989; Martinsen, 1990), however Brown and colleagues (1995) elicited greater improvements in depression with Tai Chi than with walking exercise. They suggested that forms of exercise that incorporate a cognitive relaxation component might be preferable for the reduction of depressive symptoms. Stephens (1988), found exercise, but not housework, to be negatively related to depression status, suggesting that individuals must enjoy participating in exercise in order to benefit psychologically from it. Therefore, although the effects of exercise on depression do not seem to be type-specific, relaxing and personally enjoyable activities may be the most likely ones to elicit improvements.

1.6.6 Potential Mechanisms For the Alleviation of Depression Following Exercise

1.6.6.1 Potential Physiological Mechanisms

Two main physiological mechanisms have been proposed in order to account for exercise's positive effects on psychological status. One of these proposed mechanisms, known as the monoamine hypothesis (Morgan, 1985), suggests that participation in exercise improves affect by triggering the release of norepinephrine, dopamine and serotonin in the brain. Once

released, these neurotransmitters could enhance aminergic synaptic transmission and affect arousal (Ransford, 1982). Alternatively, the endorphin hypothesis suggests that improved affect following exercise may be due to the release of endorphins, which cause reduction of pain and the production of a state of euphoria in humans (Paluska and Schwenk, 2000). Both of these hypotheses have been investigated at length, however, at this stage the exact roles played by monoamines and endorphins in the reduction of depression following exercise remain to be determined (Morgan, 1985; Leith, 1994; Paluska and Schwenk, 2000).

1.6.6.2 Potential Psychological Mechanisms

In addition to the physiological mechanisms that have been proposed to explain the positive effects of exercise on depression, some researchers have suggested that exercise may exert its influence via psychological mechanisms. The distraction hypothesis (Morgan, 1985) proposes that participation in exercise distracts the participant's attention away from negative stimuli, thereby causing improvement in depression status. This particular hypothesis has not received extensive support due to its inability to explain chronic improvements in affect that are associated with regular exercise participation; however, it may be applicable in explaining acute psychological reaction to exercise (Bahrke and Morgan, 1978). Unlike the distraction hypothesis, Bandura's (1977) self-efficacy theory suggests that improvements in exercise performance, achieved via regular participation in physical activity, cause individuals to develop increased self-confidence. This increased self-confidence could lead to increased ability to cope with daily stressors, and subsequent reduction depression status. The exact relationship between exercise, self-efficacy and depression status is difficult to experimentally isolate and examine, hence it has not yet been firmly established (Leith, 1994).

1.7 Exercise in Individuals With SCI

Physical inactivity is the most readily-modifiable CHD risk factor for individuals with SCI. Furthermore, in able-bodied individuals, participation in exercise has been shown to contribute to the reduction of other risk factors such as diabetes and insulin resistance (Ivy et al., 1999), obesity (McInnis, 2000), hypertension (Kokkinos and Papademetriou, 2000), lipid disorders (Berg et al., 1994) and psychological disorders (Leith, 1994). Current ACSM guidelines call for the regular performance of aerobic endurance training for all members of the population in an individualized manner that allows for the provision of maximal benefit with the lowest risk to the individual (ACSM, 1998). These guidelines also state that, in order to develop and maintain fitness, individuals should exercise no fewer than 2 days per week, no less intense than 40-50% of VO_2 max and no shorter than 10 minutes in duration for each session.

1.7.1 Limitations to Voluntary Exercise Performance

Unlike able-bodied individuals, those with SCI do not have normal motor control or localized autonomic control in their lower limbs, factors that have important implications with respect to the performance of exercise. First of all, individuals with SCI are usually limited to voluntary exercise that uses only the musculature of the upper body. Unfortunately, upper body exercise is typically less efficient than lower limb exercise (Glaser, 1989), and limits maximal aerobic power to between 60 and 80% of that of lower limb exercise (Hoffman, 1986). In addition, at an absolute submaximal work rate, the physiologic cost of exercise is higher for arm exercise than it is for leg exercise, eliciting higher heart rates, systemic blood pressures, and

blood lactate concentrations (Phillips et al., 1998). These factors, along with the AD experienced by some individuals with SCI can lead to premature fatigue during the performance of endurance exercise (Glaser, 1989), thereby discouraging and inhibiting involvement in cardiovascular training.

Individuals with SCI exhibit lower cardiac outputs at given levels of oxygen uptake during arm exercise relative to able-bodied individuals. However exercise performance is not necessarily inhibited by this factor (Kaprilian et al., 1998). Improvements in central circulation do not affect maximal arm exercise performance in SCI patients (Hopman et al., 1998), suggesting that arm aerobic power is limited peripherally, most likely by the small muscle mass being activated. Decreased cardiac output in an exercising individual with SCI is due to a number of factors including venous pooling in the lower limbs due to a lack of vasomotor activity and the absence of the lower limb muscle pump, and decreased myocardial contractility and heart rate due to a lack of sympathetic innervation to the heart in individuals with lesions at or above T4.

Finally, exercise performance in individuals with SCI can sometimes be limited by their inability to thermoregulate below the level of their spinal cord lesions (Sawka et al., 1989). This inability exists due to the loss of vasomotor control in the skin of the lower body, reduced sweating responses over insensate skin below the level of the lesion (Randall et al., 1966), reduced thermoregulatory responses to changes in body temperature and the absence of the lower limb muscle pump to assist in venous return and to maintain stroke volume (Sawka et al., 1989). Individuals with spinal lesions above T6 have been shown to experience difficulty maintaining a steady cardiac output during exercise in hot environments (Hopman et al., 1993), due to an

inability to adequately increase heart rate in compensation for decrements in stroke volume.

1.7.2 Effects of Arm Training

Training using an arm ergometer has been shown to elicit augmentations in VO_2 max (Miles et al., 1982; Loftin et al., 1988; Cooney and Walker, 1986; Taylor et al., 1990; Davis et al., 1991) and maximum exercise power output (Miles et al., 1982; Cooney and Walker, 1986; Taylor et al., 1990) in persons with SCI. Some authors have detected increased arterial-venous oxygen differences during arm exercise in individuals following arm ergometry training (Lofin et al., 1988; Franklin, 1989), however, Davis and colleagues (1991) observed no such adaptation in their experimental participants. Some controversy exists as to whether arm training utilizes enough muscle mass to elicit central, or myocardial, adaptations, however, both Loftin and colleagues (1988) and Davis et al. (1991) observed augmented stroke volumes and cardiac outputs in participants during submaximal arm exercise, subsequent to participation in arm ergometer training. In addition, participants trained by Clausen et al. (1973) using arm exercise had lower heart rates both at rest and during submaximal lower limb exercise after completing arm ergometry training. Thus, it seems likely that at least a small degree of central adaptation can be elicited in individuals with SCI via arm endurance training.

Studies examining differences between wheelchair athletes and untrained individuals with SCI indicate that wheelchair athletes have higher VO_2 max (Huonker et al., 1998; Zwiren and Bar-Or, 1975), oxygen pulse (Zwiren and Bar-Or, 1975), subclavian artery cross-sectional area and cardiac dimensions (Huonker et al., 1998). These findings provide further support to the concept that arm training can elicit central as well as peripheral cardiovascular adaptations in

individuals with SCI.

Few studies have been performed to examine the effects of arm ergometry training on modifiable indices of cardiovascular risk such serum lipid profiles, hypertension, obesity, diabetes and glucose tolerance and psychosocial stress in individuals with SCI. However, Hooker and Wells (1989) observed increases in HDL levels and decreases in LDL and triglyceride levels following eight weeks of moderate intensity wheelchair ergometry training, despite a lack of improvement in aerobic fitness, suggesting that arm training may present a sufficient stimulus to improve serum lipid variables in those with SCI. In another study, Taylor and colleagues (1990) were unable to elicit significant improvements in body composition in those with SCI after two months of high-intensity arm ergometry training.

1.7.3 Resistance Training

Despite the fact that resistance training is often incorporated into inpatient rehabilitation programs for those with SCI (O'Sullivan and Schmitz, 1994), very little research has been performed regarding its physiological and psychological effects. In one of the only studies to examine resistance training, Nilsson and colleagues (1975) trained seven individuals with SCI using both arm ergometry and resistance training exercises. Following the training period, they noted significant increases in VO_2 max, maximal power output, mean dynamic strength and mean dynamic muscular endurance in the study's participants. In addition, the participants reported subjective improvements in overall well-being and increased confidence in coping with daily problems. A more recent study conducted by Cooney and Walker (1986) examined the effects of nine weeks of hydraulic upper-body resistance exercise in ten individuals with SCI.

Like the previous researchers, they detected significant increases in VO_2 max and maximum power output following the training period.

The above two studies implicate resistance training as a method to increase strength and cardiovascular fitness in those with SCI, however, the effects of resistance training on cardiovascular risk factors in the SCI population remain to be appropriately investigated.

1.7.4 Functional Electrical Stimulation

In recent years, researchers have begun to search for a way to train the paralyzed lower limbs of individuals with paraplegia in order to allow them to achieve more optimal levels of cardiovascular fitness. Functional Electrical Stimulation (FES) has been employed by several researchers in order to do this. It is also thought that FES, by increasing the strength of lower limb muscles, might allow individuals with incomplete spinal disruptions to capitalize more completely on any remaining motor control they might have (Glaser, 1986). During FES, electrical stimuli are applied to the muscles of the lower limb via cutaneous electrodes which are applied to the motor points of the muscle(s) to be stimulated. These electrical stimuli are delivered at a frequency sufficient to elicit tetanic contractions in the desired muscles. FES has been used in several exercise contexts in the literature including knee extension exercise (KE), cycling exercise, hybrid arm / leg exercise and walking exercise.

1.7.4.1 FES-KE Exercise

FES-initiated KE has been shown to elicit mean increases in stroke volume (Thomas et al., 1997; Figoni et al., 1991), VO_2, cardiac output, mean arterial blood pressure, heart rate and arterial - venous oxygen difference of 41%, 130%, 18%, 11% and 57% respectively (Figoni et

al., 1991). Despite the magnitude of these responses, FES-initiated KE is not used as a modality for central cardiovascular training in most SCI individuals (Figoni et al., 1991). Increases in stroke volume and cardiac output elicited during FES-initiated KE are due primarily to the activation of the lower limb muscle pump which augments venous return to the heart.

1.7.4.2 FES Cycle Ergometer Exercise

FES cycle ergometers have been available for use in both home and clinical settings since 1985 (Faghri et al, 1992). Prolonged FES cycle ergometer training has been shown to increase the strength (Ragnarsson, 1988; Faghri, et al., 1992), endurance (Ragnarsson, 1988; Faghri, et al., 1992), bulk (Ragnarsson, 1988; Mohr et al., 1997) and density (Ragnarsson, 1988) of stimulated muscles. In addition, FES encourages muscle fibre type conversion in stimulated muscles such that the ratio of oxidative to glycolytic fibres is increased (Ragnarsson, 1988; Mohr et al., 1997). In one study, citrate synthase activity, an indicator of mitochondrial oxidation, increased after 3 months of FES cycle ergometer training and plateaued during subsequent months (Mohr et al., 1997).

Aside from incurring changes in stimulated muscle, FES cycle ergometer training has also been shown to elicit decreases in heart rate and systolic blood pressure, together with increases in stroke volume and cardiac output during submaximal exercise (Faghri et al., 1992). Hooker et al. (1992) demonstrated post-training elevations in peak power output, VO_2, heart rate, and cardiac output, however no significant changes in stroke volume, arterial - venous oxygen difference or mean arterial pressure were observed. In addition, total peripheral resistance was lower following training in this study, indicating that peripheral circulatory adaptations may occur in individuals with SCI following FES cycle ergometer training. Like the previous author,

Mohr and colleagues (1997) elicited improvements in max VO_2 with a FES cycle ergometer training program.

Collectively, the results of the above studies indicate that FES cycle ergometer training presents an exercise stimulus to individuals with SCI that is significant enough to elicit improvements in peripheral and central cardiovascular variables, as well as in muscular performance. In addition, a limited amount of recently-performed research suggests that this type of exercise program may be sufficient to elicit positive changes in glucose metabolism in individuals with SCI. Significant increases in muscle to adipose tissue ratio (Scremin et al., 1999) and intramuscular glucose transporter protein levels (Chilibeck et al., 1999) have been noted following FES cycle ergometer training.

1.7.4.3 FES Hybrid Exercise

Simultaneous performance of arm ergometry and FES leg exercise presents a larger cardiovascular training stimulus for individuals with SCI. During this hybrid type of exercise, upper body activity elicits a sympathetic cardiovascular response, which may facilitate leg exercise, while FES helps to increase blood flow to the exercising upper body via the skeletal muscle pump (Phillips, 1998). This increased upper body blood flow has been shown to facilitate augmentations in cardiac output during submaximal FES hybrid exercise, relative to arm ergometry alone, in those with SCI (Hopman et al., 1998).

In an examination of hybrid exercise using FES cycle ergometry in conjunction with arm exercise versus FES cycle ergometry alone, Mutton et al. (1997) found VO_2 to increase to its highest level during hybrid exercise, indicating that hybrid exercise is a superior cardiovascular training stimulus than is FES cycle ergometry alone. This finding has been supported by the

research of other groups (Raymond et al., 1997; Hopman et al., 1998). In addition to improved aerobic fitness, Raymond and colleagues (1997) also observed higher oxygen pulses and lower heart rates in participants during hybrid exercise in comparison with during arm ergometry alone.

These results indicate that hybrid exercise provides a superior cardiovascular training stimulus than does arm ergometry alone, while simultaneously reducing the cardiac stress associated with the activity. Little research has been performed regarding the effects of hybrid exercise on cardiovascular risk factors.

1.7.4.4 FES Walking Exercise

FES was applied to walking-type exercise as early as 1987, when independent walking was facilitated in several individuals with paraplegia using walkers and crutches over a training period lasting over 22 months (Marsolais and Kobetic, 1987).

More recently, a group of researchers in the United States have been experimenting with an ambulation system known as the Parastep 1, a microprocessor-controlled ambulation system for use with a walker. After 12 weeks of exercise training with this system, individuals with paraplegia exhibited increased common femoral artery cross sectional area, flow velocity integral, pulse volume and arterial inflow volume, resulting in improvement of lower limb blood flow (Nash et al., 1997). Increased time to fatigue, peak power output and peak VO_2 along with decreased heart rate during submaximal arm ergometry were also observed after the ambulation training, indicating that some training effects of FES walking training are transferable to other activities (Jacobs et al., 1997).

Limited research suggests that cardiovascular risk may be decreased via FES walking training. Klose and colleagues (1997) noted increases in thigh and calf girth, thigh cross-

sectional area and lean body mass and a decrease in thigh skin fold following training, indicating augmetations in muscle mass combined with reductions in adipose tissue. Participants in the same study also experienced improvements in self-concept and depression scores. Another investigation of FES walking training elicited decreases in both total cholesterol and LDL in individuals with SCI (Solomonow, 1997).

Most of the research that has been conducted regarding FES walking in those with SCI has focused on the development of gait and ambulatory capability, however, the above research suggests that this form of training is capable of improving cardiovascular fitness and reducing the risk of cardiovascular disease.

1.7.5 Body Weight Supported Treadmill Training

Body weight supported treadmill training (BWST) is another intervention that has been developed in order to permit lower limb training in those with SCI, although it has only been shown to be effective in those with incomplete injuries (Wernig and Muller, 1992; Dietz et al., 1995). During BWS training, the individual is suspended by a harness above a treadmill such that the support provided by the harness can be adjusted between 0 - 100% of the individual's body weight. When appropriate amounts of support are used, it is often possible to initiate gait patterns in individuals with incomplete SCI. If independent gait performance is not possible, physical therapists may render assistance with respect to leg movement, weight transfer and upper body posture (Wernig and Muller, 1992; Visintin et al., 1998).

Most of the research that has been conducted regarding BWST has focused on the improvement of functional locomotive capabilities in those with SCI. Accordingly, researchers

have used BWST to elicit improvements in physiological variables such as muscular strength (Wernig and Muller, 1992), endurance (Ladouceur, 1993) and organization and timing of muscle action potentials (Dietz et al., 1995). Functional improvements in independent ambulatory capabilities have also been brought about through the use of BWST (Wernig and Muller, 1992; Wernig et al., 1995)

Very little research has been published regarding the effects of BWST on cardiovascular risk factors. Gardner and colleagues (1998) published observations of BWST in a single patient with an incomplete cervical SCI. They observed a training effect for heart rate, such that the patient exhibited a lower heart rate at any absolute level of work following training. This finding indicates that BWST may present a sufficient physiological stimulus to elicit positive changes in the cardiovascular risk profiles of those with SCI, or to change work efficiency.

1.8 Summary

Since World War II, the average length of survival following spinal cord injury (SCI) has increased markedly, while the average age of injury has declined (Tator, 1993). Consequent to these changes, cardiovascular diseases have emerged as primary causes of death amongst those with SCI.

Individuals are predisposed to early development of cardiovascular disease following the sustenance of a SCI, and as a consequence, cardiovascular disease is a leading cause of death in the general population of individuals with SCI. Cardiovascular risk factors including serum lipids, physical activity, obesity, diabetes and psychosocial stress have been observed at unfavourable levels in those with SCI by various researchers. Many individuals with SCI who

also have cardiovascular disease are not aware of the secondary illness because their injuries prevent the normal transmission of symptoms, such as anginal pain, to the brain. As a result, a need exists for the performance of research that addresses how cardiovascular risk can be reduced in the population of individuals with SCI.

Some existing research suggests that exercise may be effective in reducing cardiovascular risk in those with SCI. However, as a result of their injuries, individuals with SCI are more limited than are able-bodied individuals with respect to the modalities of exercise they may choose to participate in. Much of the current research regarding exercise in those with SCI focuses on functional electrical stimulation (FES), which enables the inclusion of infralesional skeletal muscles, and has been shown to elicit positive changes in cardiac risk factors such as blood lipid profile, insulin resistance and adiposity. Body weight supported treadmill training (BWST) is another, relatively new form of exercise therapy that allows infralesional muscles to be exercised, however little is known about its effects on cardiovascular risk. Arm ergometry and resistance training of unparalyzed muscles, although they do not incorporate infralesional muscles, are exercise modalities that are simpler, less reliant upon external assistance and more economical to implement than are FES and BWST. As such, they should be closely examined as potential means to reduce cardiovascular risk in those with SCI, in accordance with current health care policy in Canada that emphasizes fiscal responsibility. Although arm ergometry has been shown to elicit improvements in blood lipid profile, the effects of resistance training on cardiovascular risk in those with SCI remain largely unexamined. More research is needed in order to evaluate the specific impact that participation in these two exercise modalities has on cardiovascular risk in individuals with SCI.

Autonomic nervous system (ANS) disruption that occurs as a result of SCI leads to alterations in cardiovascular control that have implications with respect to the physiological responses to exercise. In lesions at or above T4-T6, the heart may be affected by ANS disruption, resulting in decreased ability to increase heart rate, decreased maximal heart rate and decreased myocardial contractility. In addition, loss of most vasomotor tone and voluntary skeletal muscle control below the level of the lesion results in venous pooling which decreases cardiac preload. Together, these factors cause cardiac outputs to be decreased below normal at given levels of oxygen uptake in those with SCI. The aforementioned loss of infralesional vasomotor tone also leads to hypotension and orthostatic intolerance in many individuals with SCI, particularly those with lesions above T6, whose splanchnic vasculature is affected. Partial compensation for these difficulties occurs via renin-angiotensin mediated plasma volume expansion, although spinal reflexes affecting the infralesional vasculature may also play a role. Aside from facilitating hypotension, lack of innervation to the infralesional periphery also results in an inability to thermoregulate below the lesion level, another factor affecting the physiological response to exercise in those with SCI. In addition, disruption of the spinal cord predisposes individuals to autonomic dysreflexia (AD), a condition in which noxious stimuli below the level of the spinal lesion may elicit peripheral vasoconstriction and lead to a dangerous, hypertensive response. Most commonly, AD is brought about as a result of bladder distention, although exercise-related stimuli also have the potential to elicit the reaction.

Over the last half of the twentieth century, the focus of SCI rehabilitation has gradually shifted away from mere prolongation of living, towards the improvement of quality of life (QOL) and the promotion of functional independence (Munro, 1954; Noreau and Shephard, 1995).

Consequent to the developing interest in improving QOL following SCI, researchers have begun to devote increased attention to the concept of health related quality of life (HRQL). Assessment of HRQL involves the identification of personal attributes specifically related to health status, that are valued by an individual, and the subsequent determination of the individual's satisfaction with those attributes. HRQL is concerned with the perceived abilities of the assessee, rather than objective measures of their abilities. Several dimensions are included under the umbrella of HRQL, including global indices of HRQL, physical functioning, physical symptoms, psychological well being (PWB), social functioning and cognitive functioning (Rejeski et. al, 1996).

Most of the studies that have been conducted regarding QOL in those with SCI have not adhered to the health-related restrictions of assessing HRQL. Consequently, they have not been suitable for evaluating the effects of exercise participation on life satisfaction. In general, these studies have found the QOL experienced by those with SCI to be lower than that experienced by members of the general population. Additionally, they have established links between QOL and other variables such as medical complications, social integration, dependence on others, employment status and social support. Studies have consistently failed to establish a link between QOL and neurological status.

The HRQL dimension PWB, which encompasses self-esteem, affect, anxiety and depression, is of particular interest to clinicians dealing with those with SCI, since depression has commonly been considered as a natural adjunct to spinal injury. This expectation has been encouraged, in part, by a suicide rate that has been shown to be five times higher amongst those with SCI than it is in the general population. Although stage theorists have suggested that it is

necessary for someone to experience depression in order to recover psychologically following a SCI, recent empirical research suggests that only a minority of individuals experience clinical depression following spinal injury. Nevertheless, most studies indicate a generally increased prevalence of depression amongst those with SCI, relative to the general population.

Depression status in those with SCI has been positively linked to other variables such as medical complications, autonomy and its determining factors and failure to fulfill desired roles. Most research has failed to establish a firm association between depression status and neurological impairment.

Depression has been treated successfully in those with SCI via traditional methods including psychotherapy, coping skills training and the consumption of medication. Exercise has also been utilized as a form of treatment for depression, however its effectiveness remains largely undetermined due to inconsistent findings in the limited number of studies that have been performed to date. Amongst able-bodied individuals, however, participation in exercise has been shown to be an effective treatment for clinical depression that is preferred by patients over other therapies. Furthermore, those who incorporate exercise into their treatment for depression may be less likely to experience relapses than those who do not. More research is necessary in order to evaluate exercise as a mode of depression and negative affect reduction in individuals with SCI.

As secondary impairments, cardiovascular disease and depression represent potential manifestations of SCI that reduce life expectancy and diminish HRQL in many individuals, and therefore, should be prevented in those with SCI as much as possible. Exercise has been suggested as a preventative modality for each of these conditions, however a limited amount of

research has been performed in order to address the effects of exercise on either cardiovascular risk or depressive symptoms in individuals with SCI.

1.9 Statement of Purpose and Hypotheses

The purpose of the present study was to evaluate the effects of 12 weeks of combined arm ergometry and resistance training on ergometry endurance, muscular strength, negative affect and indices of cardiovascular risk including blood lipid profile and fasting blood glucose. It was hypothesized that participation in the training would increase ergometry endurance and muscular strength, decrease negative affect and improve blood lipid and fasting blood glucose values in experimental participants.

2.0 METHODS

2.1 Subjects

Eleven male and three female (N=14) individuals with traumatic spinal cord injury (SCI) volunteered to participate in this study. Participants were matched on the basis of time post injury and mortality risk ratings developed by Coll and colleagues (1998), which take into account the level and completeness of spinal injury. Subsequently, individuals were randomized into either exercise (EX) or control (C) groups. Average age and number of years post-injury were 38 and 12 for those in the EX group and 42 and 12 for those in the C group, respectively. All patient demographical information is summarized in appendix A.

Participants were recruited by telephoning patients listed in a database at Chedoke-McMaster Hospital in Hamilton, Ontario, as well as by promoting the study through media advertisements and cooperating with physicians involved in the treatment of individuals with SCI at Chedoke-McMaster hospital. Exclusion criteria for the current study included the presence of a pacemaker, unstable angina, chronic obstructive pulmonary disease, uncontrolled arrhythmia, elbow flexion contracture greater than 15 degrees, uncontrolled autonomic dysreflexia, recent history of non-traumatic fracture, tracheostomy, symptomatic, acute shoulder pain and participation in a supervised exercise program over the course of the trial. Individuals over the age of 45 were required to pass phase 1 of a medically supervised exercise tolerance test in order to be considered eligible for participation in the study.

Prior to agreeing to become involved in the study, each participant was informed about its procedures, risks and potential benefits as well as the fact that participation was on a completely

voluntary basis. Upon indicating that he or she understood the procedures and the inherent risks of the study, each participant was asked to provide written consent regarding their participation in the indicated experimental testing.

Participants were assessed twice during the course of the study. Following the acquisition of baseline measures, testing was repeated 3 months following baseline for C participants, or alternatively, between the 22nd and 24th training sessions for EX participants.

2.2 Assessment of Blood Variables

Total cholesterol (TC), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), triglycerides (TG), TC/HDL ratio and fasting blood glucose (FBG) were determined as follows. Participants rested their hands on a heating pad for 5 minutes in order to facilitate blood flow to the fingers. Subsequently, a finger puncture was performed using a disposable lancet (Tenderlett, International Technidyne, Edison, NJ) and a blood sample was obtained in a lithium heparin coated capillary tube (Cholestech L.D.X., Drummond Scientific Co., Hayward, CA). This blood sample was immediately transferred on to a lipid profile cassette that was then inserted into an automated analyzer (Cholestech L.D.X, Cholestech, Hayward, CA) for analysis.

Whenever possible, testing was conducted in the morning hours to facilitate the acquisition of fasting blood measures. Fasting blood glucose was not examined in participants who were unable, due to employment or other obligations, to be tested in the morning, however all other blood variables continued to be examined in these individuals. Following the blood sample, each participant was given the opportunity to consume a snack and drink some juice

prior to his or her involvement in any physical activity.

2.3 Arm Ergometry Testing

Participants exercised using arm ergometers (Monark 881, Monark Exercise AB, Varberg, Sweden) that were placed on a table whose height could be adjusted according to preference. Exercise was performed in the sitting position for all participants, regardless of whether they used a wheelchair for ambulation. Those participants who were victims of cervical injuries that affected grip strength had their hands secured to the ergometer handles using tensor bandages.

Prior to engaging in exercise, each participant read a set of instructions regarding how to use the Borg CR-10 scale (Borg, 1990) in order to rate perceived exertion (RPE), and was given the opportunity to ask questions. Subsequently, resting systolic and diastolic blood pressures (SBP and DBP) as well as resting heart rate (HR) were recorded. SBP and DBP were determined via auscultation, while HR was monitored using either a chest monitor (Polar beat, Polar CIC, Port Washington, NY) or an ear-clip monitor system (Cateye PL-6000, Cateye Co., Ltd., Osaka, Japan).

The initial testing protocol consisted of 3, successively difficult, 6 minute long ergometry sessions that were separated from each other by 2 minute rest intervals. In individuals who displayed abnormal heart rate (HR) responses to exercise, typically those with lesions above T4, work rates (WR) for each session were determined according to subjective total body RPEs (TRPE) that were supplied by participants while they exercised. In individuals who displayed expected heart rate responses to exercise, WRs 1, 2 and 3 were adjusted in order to attempt to

elicit 40%, 60% and 80%, respectively, of heart rate reserve, which was defined as the difference between resting HR and predicted maximal HR (220-age). Alternatively, for participants who did not have normal HR responses to exercise, WRs 1, 2 and 3 were adjusted in order to elicit total body TRPE scores of 1, 2 and 3 to 4 respectively. Localized arm RPE scores (ARPE) were also collected at each WR. SBP and DBP were measured via auscultation following each bout of exercise.

During post-testing, C participants completed a replication of their initial ergometry test. For EX participants, the first stage of their post-test implemented the third WR from their respective initial test, while their second and third stage WRs were determined according to the criteria of the initial testing.

2.4 Psychological Measures

Following the performance of arm ergometry, each participant completed a battery of questionnaires, which were privately administered by an experimenter in interview style. The following questionnaires were administered: the Center for Epidemiologic Studies depression scale (CES-D) (Radloff, 1977), an adaptation of Cantril's ladder of life satisfaction (Cantril, 1965), the Perceived Stress Scale (PSS) (Cohen et al., 1983), a bodily pain question from the Short-Form 36-Item Health Survey (SF-36) (Ware and Sherbourne, 1992), the modified trait version of the Exercise-Induced Feeling Inventory (EFI-C) (Rejeski et al., 1999) and perceived control questions from the Beliefs Scale (BS) (Shnek et al., 1997).

The CES-D is a measure of depression designed for use in community samples (Radloff, 1977). Its 20 questions were used to measure depression-related feelings and behaviours

experienced and exhibited by an individual during the week preceding each testing date. Although it was not possible to diagnose clinical depression using the CES-D, an individual scoring greater than 16 on the CES-D was considered to be at an increased risk of experiencing clinical depression (Fuhrer et al., 1993). The CES-D has a high degree of reliability and is correlated with other measures of depression (Radloff, 1977).

The ladder of life satisfaction utilized in the current study consisted of a pictorial representation of a numbered, 9-runged ladder. The ladder was numbered such that 9 represents the best, and 1 represents the worst, possible quality of life (QOL) that an individual could expect to have. Participants subjectively rated their overall QOL based on the ladder scale, thus identifying any perceived discrepancies between their current lives and their ideal situations. This subjective rating of overall QOL has been commonly implemented in the QOL literature (Day and Alon, 1993).

Fourteen items from the PSS was used in order to measure the amount of stress individuals associated with their respective lives' events. It has been shown to be a reliable and valid measure, suitable for the examination of nonspecific appraised stress in the etiology of disease and as an outcome measure of the level of daily stress experienced by an individual (Cohen et al., 1983).

Severity of bodily pain was measured using a single question taken from the SF-36 questionnaire (Ware and Sherbourne, 1992). The SF-36 was designed for use in clinical research as well as in general population surveys, and has been validated as a measure of physical and mental health constructs (McHorney et al., 1993).

The EFI-C, which was developed in order to assess responses to habitual physical

activity, consisted of 12 questions that examined the effects of exercise interventions on pleasant as well as unpleasant feeling states associated with exercise. It has been shown to be a reliable and valid mode of assessing changes in mood that may accompany regular participation in exercise (Rejeski et al., 1999) and was used in the present study to measure positive and negative feelings.

The BS is Shnek and colleagues' (1997) modification of the Arthritis Beliefs Scale, developed by Shiaffino and colleagues (1991), and 4 of its questions were used in the current study in order to assess participants' perceived control over their respective abilities to control the symptoms of SCI, deal with the limitations imposed by SCI, continue regular activities despite being affected by a SCI and follow their treatment regimens. The BS has been shown to be associated with an acceptable degree of reliability when implemented with individuals with SCI (Shnek et al., 1997).

2.5 Assessment of 1 Repetition Maximums

1 repetition maximum (1 RM) weight lifts were determined bilaterally for each participant for 3 different exercises which included shoulder flexion, elbow flexion and chest press. Participants who retained sufficient lower limb motor control, despite their SCI, also performed a 1 RM for knee extension. An identical protocol was followed for the determination of each 1 RM.

The first step in this protocol required the participant to perform 8 repetitions with a weight that was equal to 50% of what experimenters subjectively estimated his or her 1 RM to be. Subsequently, the participant rated the difficulty with which they completed the lift on a

scale between 1 and 10. This information was then used to select a weight that was equal to 80% of the participant's reestimated 1 RM. After this weight was lifted 3 times, and the participant again rated the difficulty of the task between 1 and 10, experimenters reestimated the participant's 1 RM a second time. If the participant successfully lifted the estimated 1 RM weight, subsequent lifts were performed using progressively increasing weights, until the actual 1 RM was determined. If the estimated 1 RM weight was not lifted successfully, subsequent attempts were performed using progressively decreasing weights, until the actual 1 RM was determined. 2 minutes of rest were provided between each 1 RM attempt, as well as between the initial lifts of 8 and 3 repetitions, respectively.

Shoulder flexion and knee extension 1 RMs were performed in the Centre for Health Promotion and Rehabilitation at McMaster University, using a wall pulley system (Hanoun, Toronto, ON). Chest press and elbow flexion 1 RMs were performed in McMaster University's student gymnasium, using a wheelchair accessible weight machine (Equalizer, Equalizer Weight Machines, Red Deer, AL).

2.6 Training Protocol

The training of EX participants was carried out twice a week until 22 to 24 sessions of exercise had been completed. C participants were instructed to continue on with their normal activities and to refrain from involvement in a regular exercise routine during the 3 months of the study. If an EX participant was absent for one or more training session, they continued to exercise beyond 11 to 12 weeks of absolute time, until they had completed 22 to 24 training sessions. Throughout the training period, able-bodied volunteers supervised individual

participants in order to ensure that exercises were being performed safely and correctly.

2.6.1 Arm Ergometry

Participants in the EX group performed two bouts of arm ergometry during each training session. Initially, each bout entailed 10 minutes of exercise, carried out at the same WR that had been used during the first stage of the initial testing. During subsequent exercise sessions, however, WR and duration of exercise were progressively increased as participants noted decreases in RPE and/or HR during the performance of their prescribed arm ergometry.

2.6.2 Resistance Training

Resistance training was carried out using wall pulley exercises, free weights and universal weight machines, however, the latter equipment was used only by those participants who were capable of independent transfers. Programs varied widely according to the individual abilities of experimental participants, however all were based upon similar principles. The numerous exercises available to participants were grouped into categories, according to the part of the body being utilized in each case. These categories included abdominals, back, chest, shoulder, biceps, triceps, wrist and legs. Participants completed 2 exercises from each of these categories, with the exception of abdominals, from which they completed one exercise, during each session. Any participant that was neurologically unable to perform exercise with a particular muscle group omitted that group's exercises from their routines. During the first 6- 8 sessions of training, participants completed 2 sets of 15 repetitions of each exercise in order to allow them to become accustomed to the training and to improve their muscular endurance. This conservative approach to the initiation of the resistance training program also helped to reduced the risk of injury to the EX group participants, many of whom depended on optimal upper body

function in order to maintain their independence. Subsequent to the initial 8 sessions, heavier weights were used and 3 sets of 10 repetitions of each exercise were performed in order to maximize improvements in strength.

2.7 Statistical Analysis

Data are presented as the mean ± standard error of the mean (SEM), and unless otherwise stated, statistical significance was set at $p \leq 0.05$. Main effects for group (EX,C) and pre-post interactions (GROUP x TIME) were examined for each blood measure independently (TC, HDL, LDL, TG, TC/HDL, FBG) using a 2-way, repeated measures analysis of variance (ANOVA). Pre-post difference scores [{(post - pre) / pre} x 100) were also calculated, and expressed as a percentage of baseline values. A 1-way ANOVA was performed in order to detect potential differences between groups (EX,C) with respect to these difference scores.

Resting HR, SBP and DBP were analyzed identically to the blood measures. Since they provided the only common reference points between pre and post tests of arm ergometry, values obtained while exercising at the third WR from the initial ergometry test were compared with the first and the third post-test WRs, for EX and C group participants, respectively. Pre-post difference scores were calculated for these data (SBP, DBP, HR, ARPE, TRPE), and expressed as percentages of pretest values. 1-way ANOVAs were performed in order to detect potential differences between groups (EX,C) with respect to these difference scores. Repeated measures ANOVAs were performed in order to examine absolute exercise data.

All of the questionnaires utilized in this study were examined for internal consistency by calculating Cronbach's alpha. Acceptable reliability was designated as $\alpha > 0.70$. Post-test

composite scores for the CES-D, positive feelings from the EFI-C, negative feelings from the EFI-C and the PSS were analyzed for significant differences between groups (EX,C) using analyses of covariance (ANCOVA)s, which controlled for any initial differences that may have been present between the groups. In each case, composite scores obtained from the initial testing were used as covariates. This type of analysis was also performed on the post-test data from Cantril's ladder. Level of statistical significance was set at $p < 0.05$. Pearson product moment correlations (PPMC)s were also computed between CES-D scores and PSS and BS composite scores and pain scores in order to look at the relationships between depression and other psychological outcomes of exercise training.

Strength measures were examined in several different ways. First of all, each measure (right and left chest press, shoulder flexion, elbow flexion) was examined for group (EX,C) main effects and interaction (GROUP x TIME) using a 2-way, repeated measures ANOVA. Pre-post difference scores were also calculated for each measure, and expressed as a percentage of pretest values. A 1-way ANOVA was performed in order to detect potential differences between groups (EX,C) with respect to these difference scores. Mean percentage changes were also calculated for each group. Subsequently, unilateral difference scores for each exercise were summed and the above statistical procedures were repeated. Statistical significance was associated with a p-value < 0.05. Changes in knee extension performance were not analyzed statistically, due to the small number of EX (N=1) and C (N=2) participants who were able to complete this exercise.

3.0 RESULTS

3.1 Baseline Values

3.1.1 Blood Variables

At baseline, participants in both experimental groups exhibited desirable levels of all blood variables except TC/HDL ratio, which was above the acceptable standard of 4.5 in both groups. No significant differences were observed between exercise (EX) and control (C) groups for any of the blood variables.

TABLE 1: Baseline Means ± SEM for Total Cholesterol, High-Density Lipoproteins, Low-Density Lipoproteins, TC/HDL and Fasting Blood Glucose.

Measure	Exercise	Control	alpha
Total Cholesterol	4.77 ± 0.40 mmol/L	4.94 ± 0.45 mmol/L	> 0.05
High Density Lipoprotein	1.14 ± 0.15 mmol/L	1.08 ± 0.09 mmol/L	> 0.05
Low Density Lipoprotein	2.75 ± 0.36 mmol/L	2.61 ±0.18 mmol/L	> 0.05
Triglycerides	1.92 ± 0.44 mmol/L	2.63 ± 0.90 mmol/L	> 0.05
TC/HDL	4.94 ± 0.88	4.88 ± 0.79	> 0.05
Fasting Blood Glucose	5.61 ± 0.51 mmol/L	5.50 ± 0.20 mmol/L	> 0.05

3.1.2 Resting Cardiovascular Measures

As seen in table 2, no statistically significant differences were observed between experimental groups at baseline with respect to heart rate (HR), systolic blood pressure (SBP) or diastolic blood pressure (DBP).

TABLE 2: Baseline Means ± SEM for Heart Rate, Systolic Blood Pressure and Diastolic Blood Pressure.

Blood Pressure	Exercise	Control	alpha
Heart Rate	77.50 ± 6.04 bpm	76.17 ± 3.25 bpm	> 0.05
Systolic Blood Pressure	107.38 ± 8.89 mmHg	127.20 ± 13.58 mmHg	> 0.05
Diastolic Blood Pressure	66.25 ± 4.26 mmHg	78.8 ± 9.95 mmHg	> 0.05

3.1.3 Arm Ergometry Performance

As seen in table 3, no significant differences were observed between experimental groups with respect to baseline cardiovascular measures, arm ratings of perceived exertion (ARPE) and total body ratings of perceived exertion (TRPE) that were obtained during stage 3 of the submaximal arm ergometry testing.

TABLE 3: Baseline Means ±SEM for Heart Rate, Systolic Blood Pressure, Diastolic Blood Pressure, Total Body Rating of Perceived Exertion and Arm Rating of Perceived Exertion Obtained During Arm Ergometry.

Measure	Exercise	Control	alpha
Heart Rate	129.83 ± 9.86 bpm	126.83 ± 14.73 bpm	> 0.05
Systolic Blood Pressure	114.50 ± 11.86 mmHg	138.500 ± 16.28 mmHg	> 0.05
Diastolic Blood Pressure	62.50 ± 4.62 mmHg	68.50 ± 9.16 mmHg	> 0.05
Total Body Rating of Perceived Exertion	4.75 ± 0.89	5.17 ± 1.01	> 0.05
Arm Rating of Perceived Exertion	5.08 ± 0.74	6.17 ± 0.53	> 0.05

3.1.4 Psychological Measures

Although no statistically significant differences between experimental groups were present at baseline with respect to any of the psychological measures, mean depression scores indicated that individuals in the C group may have been more likely to become depressed than EX group participants. Scores of 16 and above are generally considered to identify those who are prone to the development of clinical depression.

Table 4 outlines baseline data obtained from the psychological questionnaires.

TABLE 4: Baseline Means ±SEM for Quality of Life, CES-D, EFI-C and the PSS.

Measure	Exercise	Control	alpha
Quality of Life	5.75 ± 0.31	5.5 ± 0.43	> 0.05
CES-D	7.88 ± 1.73	13.83 ± 3.28	> 0.05
Positive Feelings (EFI-C)	28.13 ± 2.32	34.83 ± 3.41	> 0.05
Negative Feelings (EFI-C)	13.38 ± 0.63	11.83 ± 1.78	> 0.05
PSS	35.75 ± 3.95	42.00 ± 3.59	> 0.05

3.1.5 Strength

No significant differences in strength were present between experimental groups at baseline for any of the resistance exercises (see table 5).

TABLE 5: Summed Unilateral Strength For Elbow Flexion, Shoulder Flexion and Chest Press: Means ± SEM.

Measure	Exercise	Control	alpha
Elbow Flexion	67.86 ± 8.14	60.21 ± 7.65	> 0.05
Shoulder Flexion	32.31 ± 5.81	33.75 ± 5.52	> 0.05
Chest Press	58.00 ± 12.43	60.00 ± 10.82	> 0.05

3.2 Effects of Training

3.2.1 Blood Variables

No significant differences between the exercise (EX) and control (C) group were observed for any of the blood variables examined in the present study (see table 6). Participation in exercise did not elicit changes in the blood variables.

TABLE 6: Post-Test Means ±SEM for Total Cholesterol, High-Density Lipoproteins, Low-Density Lipoproteins, Triglycerides, TC/HDL and Fasting Blood Glucose.

Measure	Exercise Post	Control Post	Alpha
Total Cholesterol	4.70 ± 0.46 mmol/L	4.62 ± 0.59 mmol/L	> 0.05
High Density Lipoprotein	0.98 ± 0.13 mmol/L	0.90 ± 0.08 mmol/L	> 0.05
Low Density Lipoprotein	2.84 ± 0.42 mmol/L	2.35 ± 0.21 mmol/L	> 0.05
Triglycerides	1.90 ± 0.42 mmol/L	2.45 ± 0.85 mmol/L	> 0.05
TC/HDL	5.6 ± 1.02	5.58 ± 1.22	> 0.05
Fasting Blood Glucose	5.48 ± 0.39 mmol/L	5.15 ± 0.29 mmol/L	> 0.05

3.2.2 Resting Cardiovascular Measures

Analysis of between group differences in percentage change in resting heart rate (HR), via 1-way analysis of variance (ANOVA), uncovered a main effect for GROUP; $F(1, 11)=6.28$, $p=0.03$. Comparison of mean scores, indicated that individuals in the C group experienced greater percentage decreases in resting HRs than did individuals in the EX group. A 2-way, repeated measures ANOVA revealed a significant GROUP x TIME interaction; $F(1,11)=5.59$,

p=0.04; for resting HR, providing further evidence of the percentage decrease exhibited by C participants (see figure 1). Main effects for TIME and GROUP were not found to be significant in this analysis.

As seen in table 7, no statistically significant changes were observed for systolic (SBP) or diastolic blood pressure (DBP) between baseline and the conclusion of the study.

TABLE 7: Baseline and Post-Test Means ±SEM for Resting Systolic and Diastolic Blood Pressures.

Blood Pressure	Baseline (mmHg)	Post-Test (mmHg)	alpha
SBP			
EX	107.38 ± 8.89	106.38 ± 6.60	>0.05
C	127.20 ± 13.58	118.0 ± 9.54	>0.05
DBP			
EX	66.25 ± 4.26	73.75 ± 4.11	>0.05
C	78.8 ± 9.95	79.17 ± 5.77	>0.05

3.2.3 Arm Ergometry Performance

Two of the EX group participants were excluded from the arm ergometry testing. Participant four was excluded because hypotension experienced on the morning of post-testing prevented him from performing arm ergometry without experiencing light-headedness and nausea. Participant six was excluded because of a shoulder injury he had sustained during the course of the study.

No significant main effects or interactions were observed for exercise HR, SBP or DBP (see table 8).

TABLE 8: Means ±SEM for Baseline and Post-Test Heart Rates, Systolic and Diastolic Blood Pressures During Arm Ergometry.

Measure	Baseline Values	Post-Test Values
HR	(bpm)	(bpm)
EX	129.83 ± 9.86	120.83 ± 12.46
C	126.83 ± 14.73	119.00 ± 12.78
SBP	(mmHg)	(mmHg)
EX	114.50 ± 11.86	108.80 ± 13.56
C	138.500 ± 16.28	126.00 ± 12.58
DBP	(mmHg)	(mmHg)
EX	62.50 ± 4.62	74.00 ± 8.85
C	68.50 ± 9.16	77.33 ± 4.72

Although a significant main effect for TIME was observed for total body rating of perceived exertion (TRPE) scores ($F(1,10)=6.86$, $p=0.03$), main effect for GROUP and GROUP x TIME interaction were not significant (see figure 2). Differences between groups with respect to percentage decrease in total body rating of perceived exertion (TRPE) scores during exercise just missed statistical significance; ($F(1,10)=4.22$, $p=0.07$); with EX participants experiencing a greater mean percentage decrease in TRPE during exercise in comparison with C participants (see figure 3). A significant main effect for TIME was observed for arm rating of perceived exertion (ARPE) scores, however GROUP main effect and the interaction of GROUP x TIME were not significant (see figure 4). EX participants experienced significantly greater mean percentage decreases in arm rating of perceived exertion (ARPE) scores than did C participants; ($F(1,10)=5.13$, $p=0.05$) (see figure 5).

At the conclusion of the study, EX participants experienced a decrease in TRPE for a given work load, however this decrease was not statistically significant (see figure 6). No such change was observed in C participants.

3.2.4 Psychological Measures

The internal consistencies of all psychological instruments utilized in the present study were verified by calculating Chronbach's α for each one, both pre and post. Reliability coefficients for each questionnaire are listed in table 9. All scales were shown to have an acceptable level of internal consistency.

TABLE 9: Chronbach's α Values For the CES-D, BS, EFI-C and PSS.

Measure	Chronbach's α
Depression (CES-D)	
Pre	0.80
Post	0.89
Perceived Control (BS)	
Pre	0.85
Post	0.73
Negative Feelings (EFI-C)	
Pre	0.89
Post	0.94
Positive Feelings (EFI-C)	
Pre	0.89
Post	0.94
Stress (PSS)	
Pre	0.90
Post	0.88

No significant differences were observed between the EX and C group with respect to post-test ratings of general quality of life (QOL) ($F=0.001$, $p=0.98$).

Similarly, EX and C groups did not differ significantly with respect to post-test ratings of depression ($F=1.416$, $p=0.259$). However, GROUP was found to account for 11.4 percent of the variance in post-test CES-D scores, which suggests that the difference in exercise training

explained some of the between group variance in depression. The largest change in depression scores was observed for C group participants, whose scores increased, indicating that individual levels of depression increased during the study. Relative to those of the C group, the depression scores of the EX group exhibited little change over the course of the present study.

Exercise accounted for less than one percent of the variance in both positive and negative feeling scores. No significant differences between the groups were noted for these variables.

The difference between the EX and C groups with respect to post-test ratings of stress approached significance; ($F(1,14)=2.80$, $p=0.12$). Mean stress scores were lower at the conclusion of the study for EX participants than they were for C participants. GROUP accounted for 20.3% of the variance in PSS scores, providing further indication that exercise influenced the daily stress experienced by the study's participants.

Significant correlations were identified between depression, as indicated by CES-D scores, and several other psychological variables examined in a concurrent study involving the same experimental participants. Post-test CES-D scores were significantly and positively correlated with post-test ratings of bodily pain severity ($r=0.58$, $p=0.03$) and stress ($r=0.61$, $p=0.03$). A sizable, yet non-significant ($r=-0.46$, $p=0.10$), correlation was also identified between post-test measures of depression and perceived control. Thus, increased depression in experimental participants was associated with corresponding increases in bodily pain and stress. Descriptive statistics for the bodily pain and perceived control data can be found in appendix E.

A summary of the psychological questionnaire scores for the present study is presented in table 10.

TABLE 10: Means ±SEM for Baseline and Post-Test Quality of Life, CES-D, EFI-C and PSS Data.

Measure	Baseline Values	Post-Test Values	Effect Size of the Variable (ω^2)
Quality of Life			
EX	5.75 ± 0.31	5.12 ± 0.69	0.000
C	5.5 ± 0.43	5.00 ± 0.68	
CES-D			
EX	7.88 ± 1.73	8.00 ± 2.17	0.114
C	13.83 ± 3.28	16.50 ± 4.10	
Positive Feelings (EFI-C)			0.008
EX	28.13 ± 2.32	29.13 ± 2.98	
C	34.83 ± 3.41	34.50 ± 4.00	
Negative Feelings (EFI-C)			0.000
EX	13.38 ± 0.63	13.13 ± 1.37	
C	11.83 ± 1.78	12.33 ± 1.26	
Perceived Stress PSS			0.203
EX	35.75 ± 3.95	33.00 ± 3.02	
C	42.00 ± 3.59	42.00 ± 3.48	

3.2.5 Strength

Two-way, repeated measures ANOVAs did not reveal significant main effects for GROUP or TIME, nor did they identify GROUP x TIME interactions for any of the individual or summed unilateral resistance exercise results. 1-way ANOVAs, examining between group differences in post-test percentage strength gains uncovered a main effect for GROUP for left elbow flexion only; ($F(1,14)=4.95$, $p=0.05$); although statistical significance was approached for other exercises such as right elbow flexion ($p=0.11$) and right shoulder flexion ($p=0.08$) (see figure 7). 1-way ANOVAs examining between group differences in percentage improvement in summed unilateral resistance exercise performance indicated no significant findings, although

summed biceps (p=0.07) and summed deltoid (p=0.08) values approached significance (see figure 8).

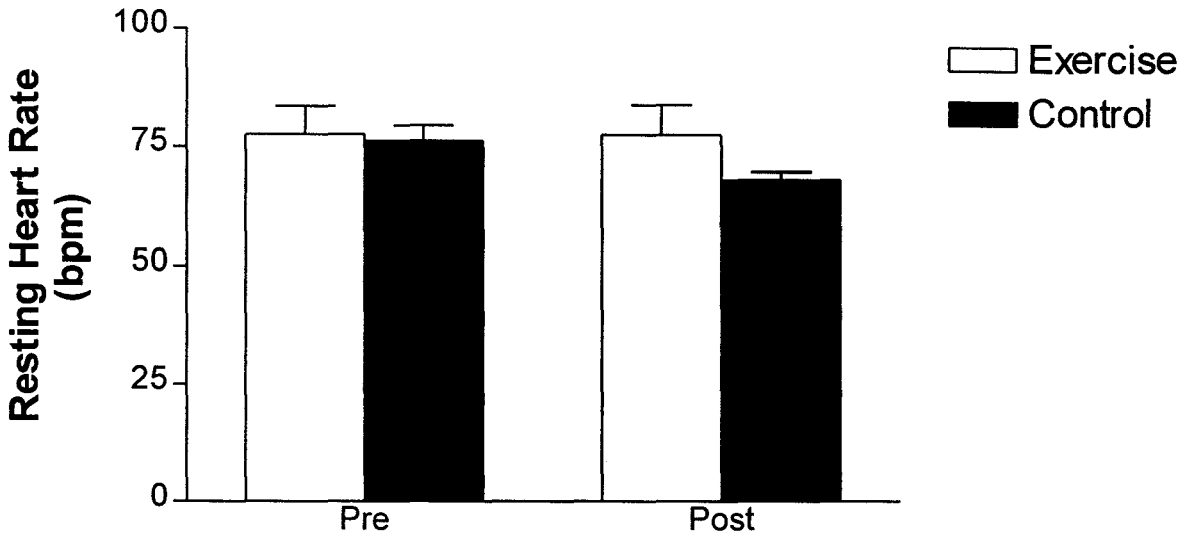

FIGURE 1: Mean resting heart rates: pre and post. Error bars indicate SEM.

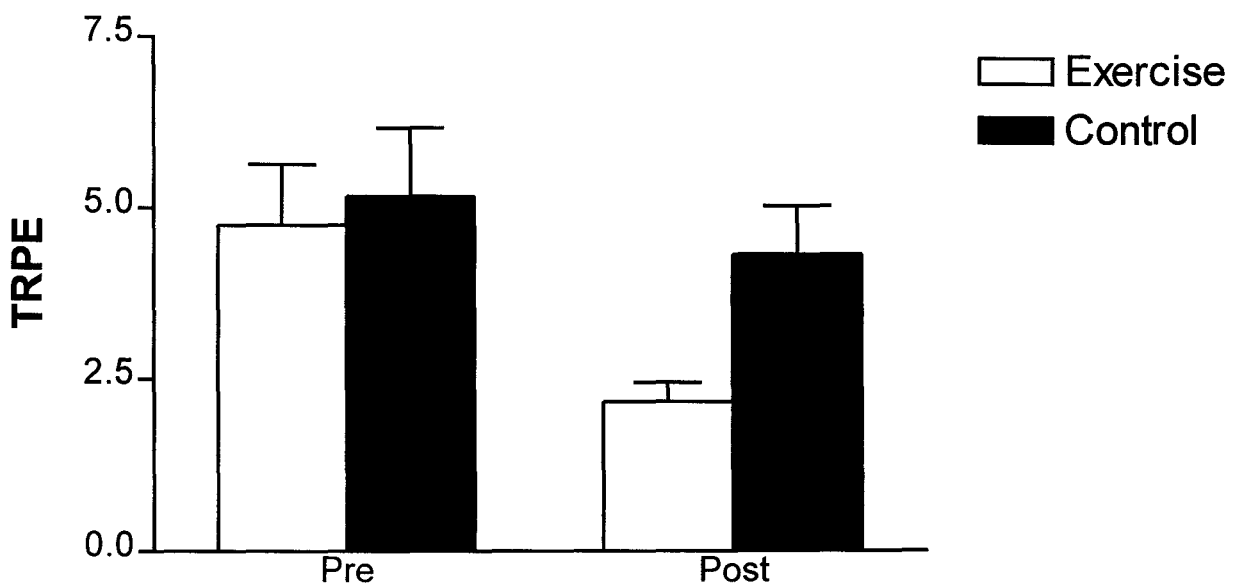

FIGURE 2: Mean TRPE at the work load used for stage three of baseline arm ergometry testing: pre and post. Error bars indicate SEM.

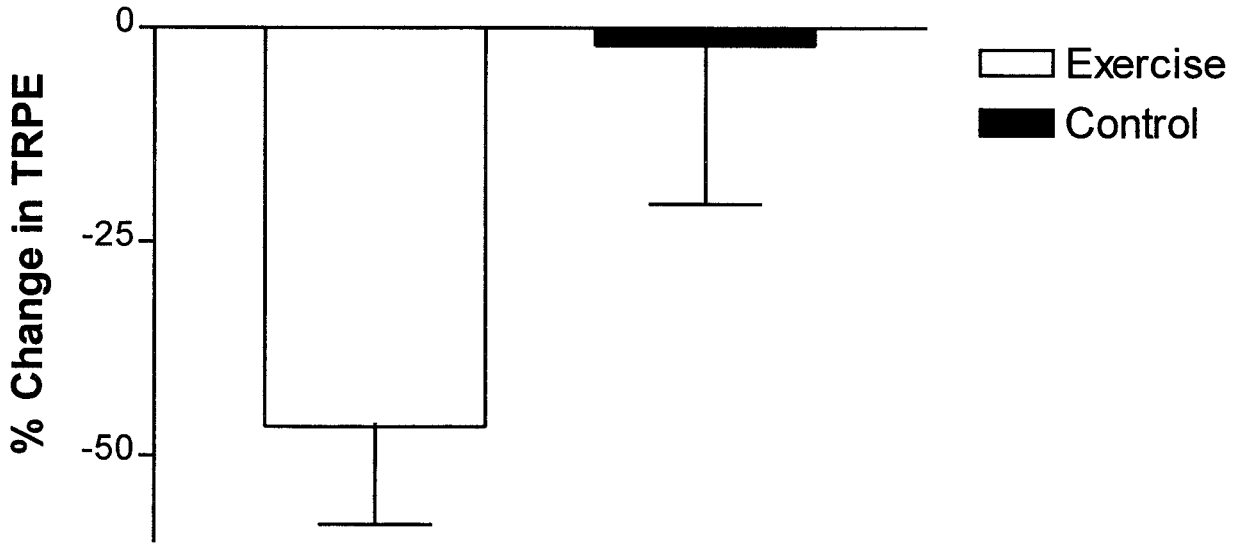

FIGURE 3: Mean percent change in TRPE reported during exercise at the work load used for stage three of baseline arm ergometry testing. Error bars indicate SEM.

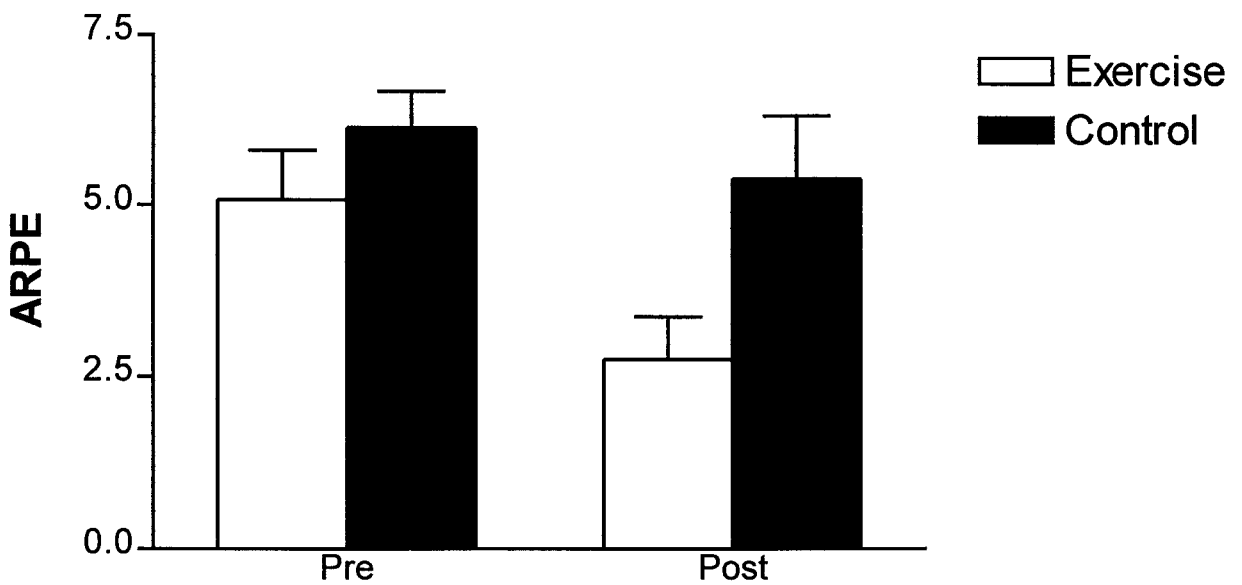

FIGURE 4: Mean ARPE reported during exercise at the work load used for stage three of baseline arm ergometry testing: pre and post. Error bars indicate SEM.

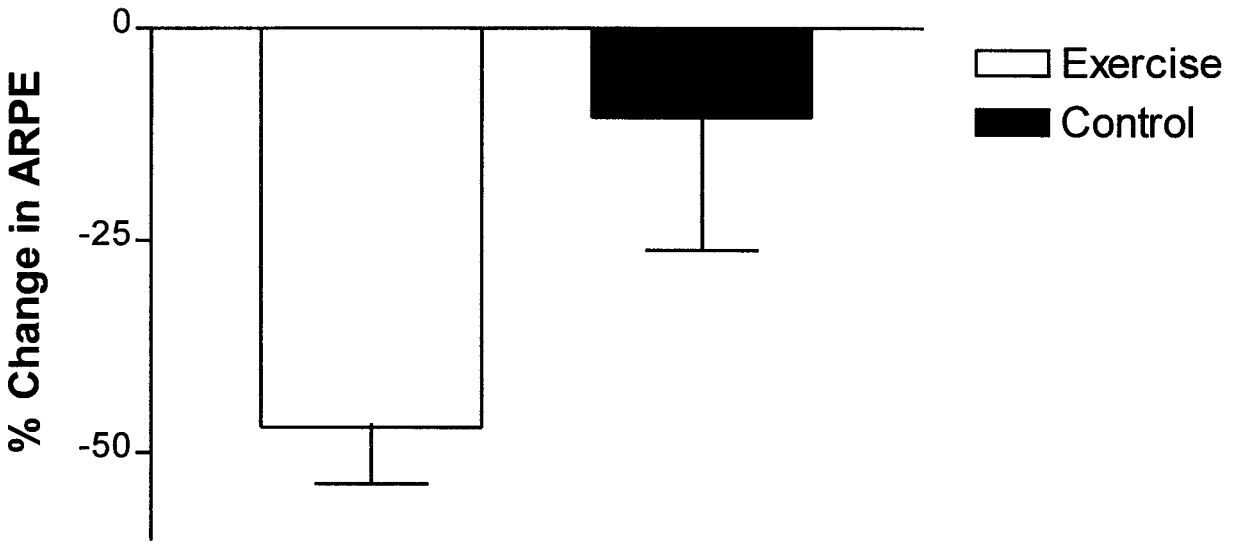

FIGURE 5: Mean percent change in ARPE reported during exercise at the work\ load used for stage three of baseline arm ergometry testing. Error bars indicate SEM.

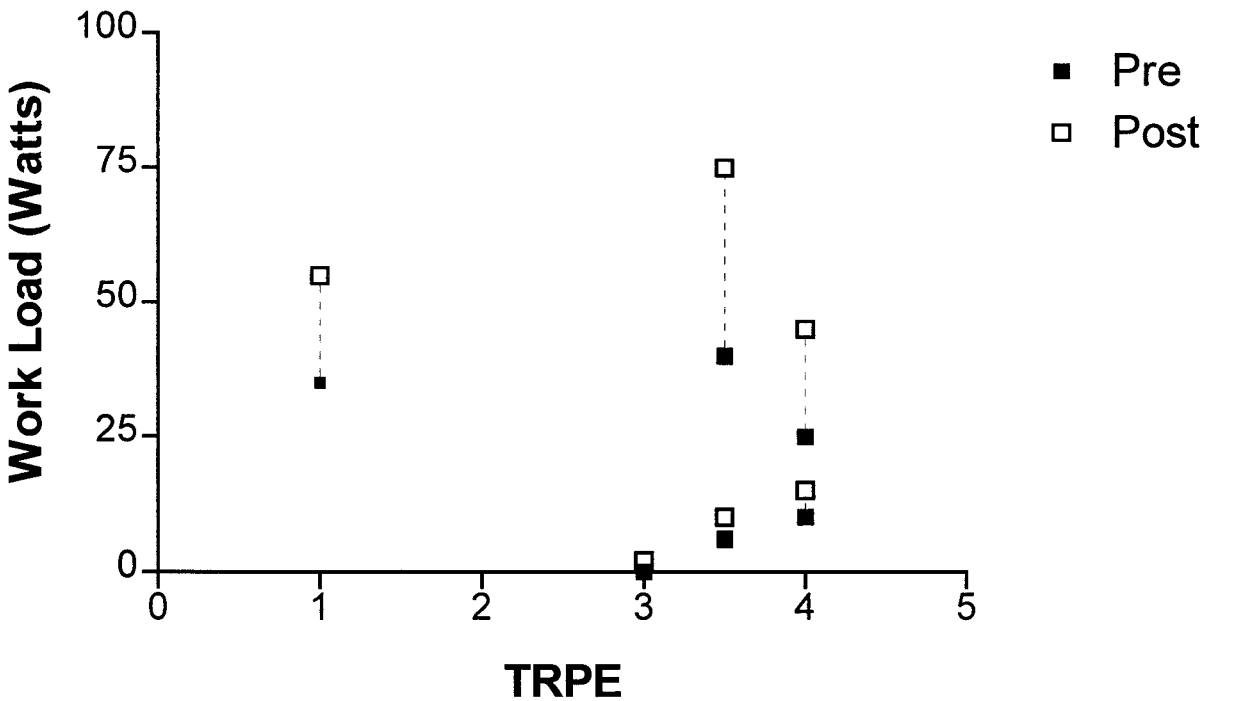

FIGURE 6: Pre-post comparison of work load associated with a given TRPE for individuals in the EX group.

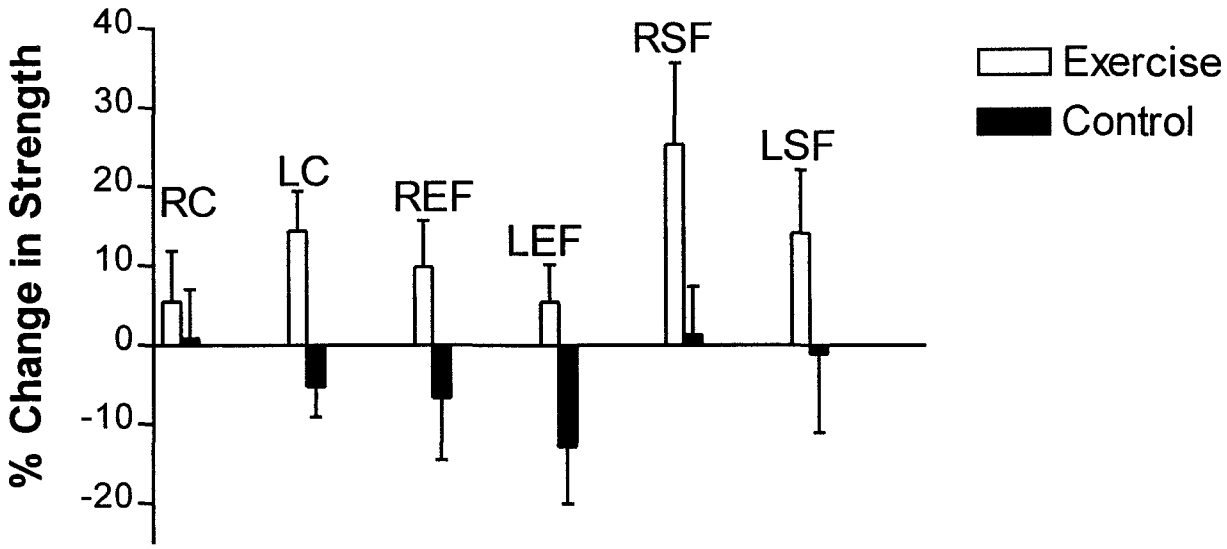

FIGURE 7: Mean percent change in strength for right chest press (RC), left chest press (LC), right elbow flexion (REF), left elbow flexion (LEF), right shoulder flexion (RSF) and left shoulder flexion (LSF). Error bars indicate SEM.

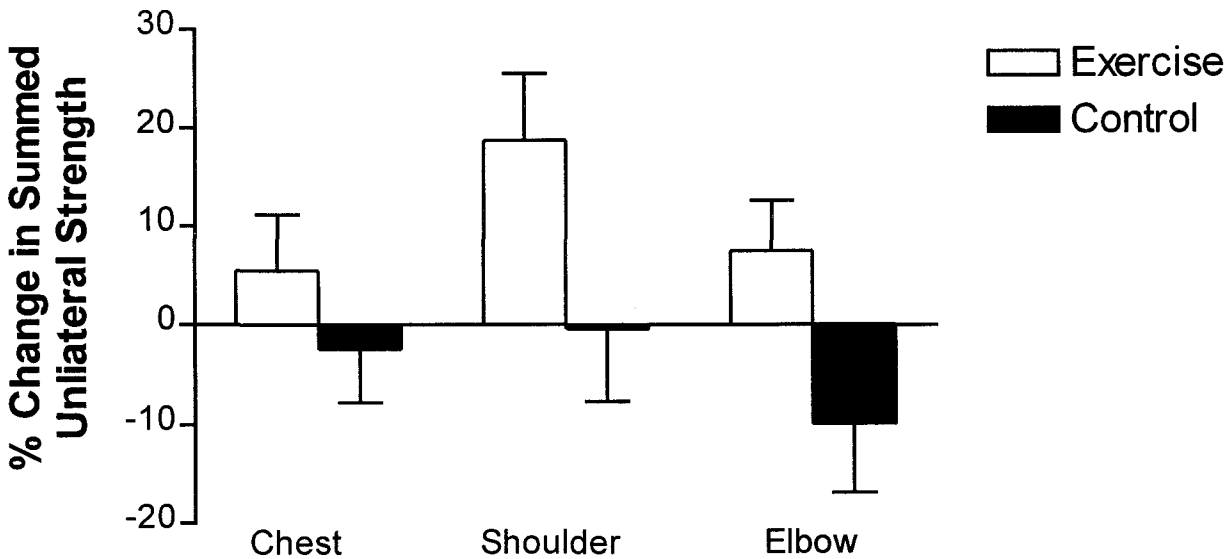

FIGURE 8: Mean percent change in summed performance for unilateral chest press, shoulder flexion and elbow flexion. Error bars indicate SEM.

4.0 DISCUSSION

Regular participation in exercise has been identified as an important means of reducing both cardiovascular risk (ACSM, 1998) and depressive symptoms (Martinsen, 1990) in the able-bodied population. However, despite the fact that individuals with spinal cord injury (SCI) may experience elevated risk with respect to the development of both cardiovascular disease and depression, little research has been conducted regarding the effects of exercise on their cardiovascular risk profiles and depressive symptoms. This study represents one of the only pieces of research that addresses these issues. Furthermore, it does so using arm ergometry and resistance training, two exercise modalities that are amongst those most commonly available to individuals with SCI. In contrast, most of the current research regarding exercise in those with SCI focuses on other modalities, such as functional electrical stimulation (FES) and body weight supported treadmill training (BWST), that allow the lower limbs to be incorporated in to the exercise. Researchers have noted improvements in cardiovascular risk factors (Solomonow, 1997; Chilibeck et al., 1999; Scremin et al., 1999) and indices of depression (Alexander and Sipski, 1990; Guest et al., 1997; Klose and colleagues, 1997) following FES training, however these benefits remain unavailable to most individuals with SCI due to the cost, equipment and personnel FES exercise training requires. One of the most significant aspects of this study is that it implements modes of training which are relatively inexpensive and accessible to individuals with SCI, and thus its findings are practically applicable to a large proportion of the SCI population.

4.1 Blood Variables

Individuals with SCI experience increased risk of developing heart disease (Phillips et al., 1998). In the current study, mean values of total cholesterol (TC), low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL) and triglycerides (TG) were within the American College of Sports Medicine's (ACSM) desirable ranges of <5.2 mmol/L, <3.4 mmol/L, >0.9 mmol/L and <2.3 mmol/L respectively, for both exercise (EX) and control (C) groups (American College of Sports Medicine, 1995). In contrast, mean TC/HDL ratios were above the desirable range cutoff value of 4.5 for both groups. This particular finding is indicative of the presence of increased cardiovascular risk for the participants in the current study, despite their collective profile of acceptable absolute blood lipid values. It may therefore be possible, as suggested by Bauman and colleagues (1999b), that ideal absolute blood lipid values may differ in persons with SCI from those of the general population (Bauman et al., 1999b).

The higher than expected levels of HDL observed in the current study's participants may be indicative of a selection bias, since HDL levels have commonly been found to be low in individuals with SCI (Bauman et al., 1992; Brenes et al., 1986; Krum et al., 1992; Maki et al., 1995; Shetty et al., 1992; Washburn and Figoni, 1999; Zlotolow et al., 1992). In addition, cross-sectional research has identified a positive relationship between activity level and serum HDL concentrations in individuals with SCI (Dearwater et al., 1986). It is possible that the volunteers in the present study may have belonged to a health-conscious, or unusually active, subset of the entire population of individuals with SCI, attracted by the prospect of participating in supervised

exercise. If this situation was the case, it may have lead to the recruitment of individuals who exhibited healthier blood lipid profiles. However, mean LDL and TG values observed in the present study were not abnormally elevated in either group of participants, and mean TC levels in both groups of participants were not exceedingly low. The elevated TC/HDL ratios observed in individuals from both groups are in agreement with the findings of Maki and colleagues (1992), but are not consistent with those of two other groups (Bauman et al., 1992; Janssen et al., 1997). Additional research regarding TC/HDL ratios in individuals with SCI is required in order to establish normative values for the population.

With respect to glucose metabolism, disorders such as elevated fasting blood glucose (FBG) and insulin levels (Bauman and Spungen, 1994; Duckworth et al., 1980), as well as decreased insulin sensitivity (Karlsson, 1999) and glucose tolerance (Bauman and Spungen, 1994) have been reported in individuals with SCI.

In contrast with other researchers' observations of FBG in individuals with SCI (Bauman and Spungen, 1994; Duckworth et al., 1980), mean levels of FBG were already found to be below the acceptable cut-off value of 6.1 mmol/L (Meltzer et al., 1998) at baseline for both groups of participants in the present study. This finding suggests that individuals recruited for the study were not subject to abnormalities of glucose metabolism, a further indication that this study's participants may have belonged to a health-conscious subset of the overall population of individuals with SCI. However, since glucose tolerance was not examined in the current study, it was not possible to completely rule out the presence of glucose metabolism abnormalities in the study participants.

In a study that was performed over a decade ago, Hooker and Wells (1989) demonstrated

that it was possible to elicit increases in HDL levels and decreases in LDL and TG levels in individuals with SCI using arm ergometry training. Surprisingly, the effects of arm ergometry on blood lipids in those with SCI have remained largely uninvestigated ever since. Furthermore, few, if any, studies have been conducted regarding the effects of arm ergometry training on FBG levels in individuals with SCI. Similarly, upper-body resistance training has not been investigated as a potential mode of improving blood lipid profiles or FBG levels in individuals with SCI. The current study represents the first to examine the combined effects of arm ergometry and resistance training on blood lipid profiles and fasting blood glucose levels in individuals with SCI.

In contradiction with the findings of Hooker and Wells (1989), participants in the EX group exhibited no significant changes in any of the blood lipid variables following participation in the training protocol. The most likely explanation for the absence of change in lipid variables in this study is that participants already exhibited desirable levels at baseline, leaving little room for improvement. In congruence with the blood lipid results, participation in exercise did not cause a change in mean FBG for EX group participants. Once again, the absence of change was likely due to the fact that mean FBG was not elevated in EX group participants at baseline.

4.2 Resting Cardiovascular Measures

As expected, mean resting heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) did not differ between experimental groups at baseline. Decreased resting heart rate (HR) is indicative of a trained state, and is commonly observed in individuals following extended periods of regular participation in physical activity. Consequently, it was

expected that participation in the current study's exercise protocol might elicit a reduction in resting HR for EX group participants. Paradoxically, individuals in the C group experienced significant decreases in resting HR following the training period, while those in the EX group did not. Each of the six individuals in the C group exhibited a lower resting HR at their post-test than they did at baseline. One possible explanation for this unexpected finding is that individuals in the EX group may have experienced increased anxiety during their post-testing as a result of genuine concern over finding out if they had improved ergometry performance through participating in the training. This anxiety may have translated into elevations in resting HRs. Alternatively, the C participants may have been more relaxed during the post-test than they had been during baseline testing, which could have contributed to their lower resting HRs. This problem could have been avoided if each participant's resting HR had been checked at a different point in the experimental protocol, such as upon presentation to the lab.

The absence of any change in resting HR following training for the EX group may be an indication that the training protocol utilized in the present study was insufficient to elicit central cardiovascular training adaptations. Research by Davis and colleagues (1991) indicates that the elicitation of central training adaptations in individuals with SCI is possible using arm ergometry. However the training protocols they implemented incorporated higher intensities and increased durations of training than the one used in this study.

No changes in resting systolic (SBP) or diastolic (DBP) blood pressures were noted in either group of participants following the completion of the study. The absence of change observed in these particular variables was most likely due to the fact that baseline values were not elevated above normal (American College of Sports Medicine, 1995) in either group of

participants. Consequently, it would not have been possible to incur much improvement in the blood pressures of experimental participants, regardless of mode of intervention utilized in this study.

4.3 Arm Ergometry Performance

No significant difference in HR was observed between groups during the performance of arm ergometry during either baseline or post-testing. This finding supports the suggestion that the difference in resting HR observed between C and EX participants during post-testing resulted from differences in the amount of anxiety experienced by individuals in each group. While the lack of a decrease in exercise HR may suggest that the training protocol implemented in the present study was insufficient to elicit a cardiovascular training effect, there exists another possible explanation. The majority of individuals in the EX group had spinal lesions at or above T4, which is the level of autonomic cardioacceleratory control. Therefore, it may not have been possible for these individuals to decrease their exercise HR responses via participation in training.

Davis and colleagues (1991) examined the effects of twenty-four weeks of thrice-weekly arm ergometry training, in individuals with non-cervical SCI. The authors divided experimental participants into four exercise groups and one control group. Each exercise group was assigned a specific ergometry protocol consisting of either high intensity (70 % of VO2max) for long duration (40 minutes per session), low intensity (50% of VO2max) for long duration, high intensity for short duration (20 minutes per session) or low intensity for short duration exercise. Following the training period, they noted decreases in HR for a given work load for all

participants except those in the low intensity for short duration exercise group and the control group. Based on this finding, it is likely that individuals in the present study did not achieve improvements in central cardiovascular function via the performance of arm ergometry training because the training performed was not of sufficient intensity and duration to elicit the desired improvements. However, it is important to note that the participants in Davis and colleagues' (1991) study were paraplegics who exhibited normal HR responses to exercise. The majority of the EX participants in the current study had experienced either cervical or high-level thoracic SCI, and in many cases, were therefore unable to exercise as intensely or as long as those in the previous study. In addition, since abnormal HR responses to exercise were exhibited in the majority of EX group participants, the only method available to researchers for monitoring exercise intensity was the use of ratings of perceived exertion.

In contradiction with the HR data, percentage decreases in arm rating of perceived exertion (ARPE) scores were significantly greater amongst EX participants than C participants, and between group differences in percentage decrease in total body rating of perceived exertion (TRPE) came close to achieving statistical significance. These findings suggest that those in the EX group improved their tolerance of arm ergometry, whereas C group participants did not. Alternatively, differences in percentage decreases in ARPE and TRPE scores amongst individuals in the EX group may also have occurred as the result of increased experience using the CR-10 scale (Borg, 1990) to rate perceptions of exertion. This alternative explanation seems unlikely, however, when one considers the trend of decreased TRPE at a given work load that was exhibited by EX group participants, but not by C group participants, during post-testing. Thus, although HR during submaximal exercise did not decrease following the training period,

changes in both ARPE and TRPE suggest that individuals in the EX group improved their capacity to perform arm ergometry as a result of the training.

4.4 Psychological Measures

The exercise protocol implemented in the current study had no significant influence on quality of life (QOL). However, since QOL is determined by an extremely broad scope of variables, many of which, such as employment status, are not directly related to exercising, it was not surprising that participation in an exercise program did not change perceptions of overall QOL in the EX group. It was anticipated, however, that exercise would positively influence some health-related determinants of QOL, namely depression, affect and perceived stress, and in doing so, improve the health-related quality of life (HRQL) experienced by individuals in the EX group.

Although involvement in exercise has been shown to be an effective treatment for clinical depression (Greist et al., 1979; Martinsen, 1985; Martinsen, 1990), studies examining the effects of exercise on depression status in individuals with other medical disorders have yielded conflicting results (Emerey et al., 1998; Kugler et al., 1994; Stern and Cleary, 1982; Taylor et al., 1986). Several researchers have demonstrated positive changes in depression in individuals with SCI via the implementation of functional electrical stimulation (FES) exercise (Alexander and Sipski, 1990; Guest et al., 1997; Klose et al., 1997), however one author observed negative changes (Bradley, 1994) due to unrealistic expectations on the part of study participants.

There existed some disparity in baseline depression scores between the EX and C groups in the present study. Whereas participants in the EX group exhibited no evidence of depression

at the onset of the study, individuals in the C group exhibited an average score that was relatively close to sixteen, the cut-off for identifying individuals who are at an increased risk of developing clinical depression. The absence of depression in the EX group at baseline may have increased the difficulty of eliciting significant improvements in depression scores through the introduction of a potential floor effect, whereby it might not have been possible to lower depression scores beyond their initial levels. Floor effects have previously been noted in the literature when exercise has been implemented in attempts to decrease depressive symptoms in individuals who are not depressed (Raglin, 1990).

In the current study, regular participation in exercise without FES did not elicit significant changes in depression status in individuals with SCI. However, GROUP was found to account for 11.4 percent of the variance in post-test depression, with the EX group having less depression than the C group at the conclusion of the study. It seems likely, therefore, that statistically significant training adaptations were not observed in part because the recruitment of a small number of participants limited statistical power.

Unexpectedly, the greatest magnitude of change in CES-D scores occurred for the C group (mean 13.83 ± 1.73 at baseline; 16.50 ± 4.10 post). It is possible that exclusion from the exercise program influenced C group participants to become slightly more depressed by the end of the study than they had been at baseline.

Participation in the exercise program did not significantly affect positive and negative exercise-induced feelings experienced by experimental participants. The extremely small differences observed between baseline and post-test values for both positive and negative exercise-induced feelings makes the possibility of type I error for the affect data unlikely.

GROUP accounted for less than one percent of the variance in positive and negative feeling scores, indicating the absence of a relationship between group status and affect in the current study. Although C participants achieved higher depression scores than did EX participants, both at baseline and following the execution of the experimental protocol, this trend was reversed for feeling scores, with mean C group scores for positive and negative feelings being higher and lower, respectively, than their EX group analogues. Collectively, the above findings suggest that depression and affect, as indicated by exercise-induced feelings, are not closely related psychological constructs. Alternatively, they may suggest that the modified exercise-induced feeling inventory (EFI-C) is insensitive to positive and negative affect in individuals with SCI. Although the EFI-C has been validated for use in the able-bodied population, additional research is required in order to determine its suitability for implementation in studies involving individuals with SCI.

As was the case for depression and affect, no significant difference in perceived stress was detected between experimental groups at the time of post-testing. However, it is likely that a significant difference may have been found if statistical power had been augmented through the recruitment of a much larger sample, since EX stress scores declined during the study, while those of the C group did not. That GROUP accounted for 20% of the variance in the post-test stress scores provides convincing evidence of the existence of a relationship between exercise participation and perceived stress in this study's participants. This finding is particularly important since living with a SCI can often be very stressful as a result of difficulties associated with such things as the performance of activities of daily living and the fulfillment of desired social roles. Perhaps exercise serves a buffering role against stress.

Significant, positive correlations were observed between depression and ratings of bodily pain severity and perceived stress at the conclusion of the experimental protocol. The relationship between depression and bodily pain observed in this study supports the observations of other researchers (Cairnes et al., 1996; Rintala et al., 1998; Scivoletto et al., 1997) that there exists in individuals with SCI a correlation between medical complications and depression. The relationship between stress and depression that was observed may indicate that depressed individuals with SCI may experience difficulty coping with stressful events. Alternatively, individuals with SCI who must deal with abnormal amounts of stress in their daily lives may experience difficulty coping with depression. Thus, the findings of the present study support the incorporation of coping effectiveness training into protocols for the treatment of depression and negative affect in individuals with SCI.

4.5 Strength

The resistance training protocol implemented in the present study was insufficient to elicit statistically significant differences in strength between the EX and C groups. However, trends were observed which indicated that strength was increasing in EX group participants. Three factors may have contributed to the lack of statistical significance in the strength measures.

First, a relatively small sample of participants was recruited for involvement in the study. Considering the trends present in the data which pointed towards increased improvement in strength for EX group participants, it may have been possible to demonstrate statistically significant increases in strength for the exercise group using the existing protocol had a large sample been recruited.

Second, the strength training protocol utilized in the study was quite conservative. In order to both minimize the possibility of injury to the participants and maximize adherence to exercise protocols, participants in the EX group exercised only twice a week. Had EX participants been asked to exercise three times a week, as was the case in another study regarding resistance training in individuals with SCI (Cooney and Walker, 1986), it is more likely that training effects for strength would have been elicited. In addition to the low frequency of training, the exercise protocol also incorporated an initial acclimatization period, lasting between six to eight sessions, during which the weights that were lifted were light enough that participants could perform two or three sets of fifteen repetitions. This was done in order to minimize the risk of injury to EX group participants, who were performing resistance training with the upper-body muscles that were essential to allow them to perform their activities of daily living (ADL). In many cases, injuries could have resulted in the loss of independence for a participant. Nevertheless, had the initial acclimatization period been eliminated, or significantly shortened, it may have been possible for participants to have achieved greater augmentations in strength, potentially leading to the achievement of statistical significance for between group differences in the resistance exercise data.

Third, although participants' strength measures were obtained only for chest press, shoulder flexion and elbow flexion, the training protocol utilized in the current study incorporated a much wider range of exercises. The purpose of the wide range of exercises incorporated into the training protocol was to enable participants in the EX group to achieve gains in functional, upper body strength. Had EX participants only taken part in strength training for the three movements being tested, they may have been able to train the involved muscles

more vigorously, potentially leading to improvements in the performance of these exercises that may have been statistically significant. However, gains in strength for only those three movements could not have lead to the same amount of functional improvement as gains in strength achieved through an overall, upper-body resistance training program such as the one implemented in the current study. Although function was not measured during the current study, a concurrent study involving the same cohort of subjects as the current one is examining this issue.

4.6 Summary

Arm ergometry and resistance training represent two modes of exercise that are relatively inexpensive and commonly available to individuals with SCI, yet their effects on cardiovascular risk and psychological profile have not been appropriately investigated. This study represents the first effort to examine the combined effects of arm ergometry and upper-body resistance training on blood lipid profile, FBG and psychological well being (PWB) in individuals with SCI. Results indicated that twenty two to twenty four sessions of exercise, performed on a twice-weekly basis, were insufficient to elicit statistically significant, positive changes in any of the aforementioned variables. However, since participants already exhibited acceptable levels of absolute blood lipid variables, FBG and depression at the onset of the study, it may have been difficult for significant improvements to be elicited through exercise training. Improved tolerance of arm ergometry in EX group participants was indicated by significant differences between the EX and C groups with respect to percentage improvements in ARPE scores. Statistically significant improvements in strength were not observed in the EX group, although

mean changes suggested the existence of a trend for a training-induced improvement in strength. Utilization of a small sample size, a conservative strength training protocol and a wide array of resistance training exercises were likely contributors to the absence of statistically significant changes in strength.

5.0 RECOMMENDATIONS

Participation in exercise has been shown, both in able-bodied individuals and those with SCI, to be associated with numerous physiological and psychological benefits. Since individuals with SCI often experience increased risk for the development of cardiovascular diseases, as well as lower quality of life and increased depression in comparison with their able-bodied counterparts, a need exists for the performance of research that addresses the potential role of exercise in the management of these issues.

The current study was limited to the examination of the effects of arm ergometry and resistance training in a sample of relatively healthy individuals with SCI. Future research should concentrate on more generally representative samples of individuals with SCI. This goal might be achieved through the development of a new recruitment strategy that involved past SCI exercise study participants. Engaging individuals with SCI as recruiters might facilitate the attraction of peers who would not normally seek out opportunities to become involved in an exercise program.

Individuals in the control group of the present study experienced an increase in depression. Although this increase was not statistically significant, it remains a cause for concern in the development of future exercise training studies involving participants with SCI.

Although it is desirable, from an epistemological point of view, to assign experimental participants to control groups during the performance of exercise training research, it may be unethical to do so when the participants perceive that exercise is associated with a significant health benefit. For this reason, the use of control groups in exercise training studies involving individuals with SCI is not recommended, from an ethical perspective. Studies with crossover designs may provide potential alternatives for determining the effects of exercise.

In order to maximize adherence to the exercise protocol and minimize the occurrence of injuries to participants in the current study, exercise was only performed twice a week, until 22-24 sessions had been completed. Future studies hoping to demonstrate significant improvements in strength and ergometry performance should consider incorporating an exercise protocol that is either performed three times a week, or that is performed over a longer period of time than the one implemented in the present study.

Since ratings of perceived exertion are highly subjective, and HR is an unreliable physiological reference point in individuals with lesions above T4-T6, future research examining improvements in arm ergometry performance brought about by training in individuals with SCI should consider the use of maximal oxygen uptake or maximal work capacity as an index of ergometry performance during testing. Doing so would allow for the completely non-subjective, empirical comparison of baseline and post-test performance. It would not be logistically practical, however, to utilize oxygen uptake as a determinant of training workload.

In sum, the data obtained from the present study do not provide statistically significant evidence that participation in an exercise program involving arm ergometry and resistance training leads to improvements in strength, cardiovascular fitness, blood lipid variables, fasting

blood glucose or psychological well being. However, limitations to statistical power caused by the recruitment of a small number of experimental participants reduced the likelihood of achieving statistically significant improvements in the aforementioned variables. Furthermore, the participants in the present study exhibited atypically healthy blood lipid profiles and favourable psychological profiles at baseline, making improvement of these variables difficult. Further research, involving a much larger sample of experimental participants, is required in order to elucidate more clearly the effects of the exercise protocol utilized in the present study on blood lipids, fasting blood glucose, arm ergometry performance, strength and psychological well being of individuals with SCI. It would be of particular interest to include individuals with SCI who exhibit undesirable blood lipid profiles, abnormal fasting blood glucose levels and/or depression in this future research.

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APPENDIX A:

DEMOGRAPHICAL INFORMATION

Demographical Information

	Subject	Age	Gender	Years Post	SCI Level
Exercise	1	40	M	23	Quad
Group	2	39	M	14	Para
	4	34	M	4	Quad
	5	26	M	3	Quad
	6	40	M	23	Para
	12	49	M	3	Para
	13	32	M	10	Para
	14	45	F	13	Para
Mean		**38.125**		**11.625**	
SD		**7.31803**		**8.245128**	
Control	3	35	M	17	Quad
Group	7	29	M	5	Para
	8	43	F	24	Para
	9	43	M	3	Para
	10	44	F	20	Para
	11	63	M	3	Para
Mean		**42.8333**		**12**	
SD		**11.496**		**9.423**	

APPENDIX B:

RAW DATA

Blood Measures (mmol/L)

		Pre						Post					
	Subject	TC	HDL	LDL	TG	TC/HDL	Glucose	TC	HDL	LDL	TG	TC/HDL	Glucose
Exercise	1	4.58	1	2.67	2.8	7.3	7.57	4.36	0.49	2.1	3.72	8.9	7.76
Group	2	5.89	1.66	3.81	0.95	3.6	5.11	5.99	1.45	4.08	0.98	4.1	5.55
	4	3.81	1.07	2.42	0.7	3.6	4.98	3.72	0.98	2.32	0.91	3.8	5.27
	5	3.05	1.47	1.16	0.92	2.1	4.72	2.81	1.3	1.03	1.04	2.2	4.62
	6	5.11	1.21	2.07	3.99	4.2	.	4.95	0.96	2.83	2.52	5.1	5.01
	12	6.64	0.99	4.45	2.6	6.7	5.69	6.94	0.88	4.81	2.73	7.9	5.16
	13	4.55	0.49	2.84	2.66	9.2	.	4.87	0.5	3.11	2.78	9.8	.
	14	4.53	1.61	2.61	0.7	2.8	.	3.92	1.29	2.41	0.51	3	4.99
	Mean	**4.77**	**1.14**	**2.75**	**1.92**	**4.94**	**5.61**	**4.70**	**0.98**	**2.84**	**1.90**	**5.60**	**5.48**
	SD	**1.127**	**0.433**	**1.010**	**1.253**	**2.496**	**1.150**	**1.311**	**0.359**	**1.181**	**1.175**	**2.876**	**1.045**
	SEM	**0.398**	**0.153**	**0.357**	**0.443**	**0.882**	**0.514**	**0.463**	**0.127**	**0.418**	**0.415**	**1.017**	**0.395**
Control	3	4.09	1.33	2.31	0.97	3.1	4.93	3.42	1.04	1.84	1.16	3.3	4.67
Group	7	4.32	0.96	2.67	1.5	4.5	5.55	5.39	0.79	2.8	3.94	6.9	5.57
	8	4.96	1.09	2.94	2.04	4.6	.	4.49	1.04	2.92	1.16	4.3	.
	9	6.72	0.87	.	6.45	7.7	5.66	7.17	0.65	.	5.98	11	5.98
	10	3.84	1.36	2.11	0.82	2.8	5.88	3.63	1.17	2.13	0.71	3.1	4.37
.	11	5.69	0.86	3.01	3.97	6.60	.	3.59	0.73	2.07	1.72	4.90	.
.	**Mean**	**4.94**	**1.08**	**2.61**	**2.63**	**4.88**	**5.51**	**4.62**	**0.90**	**2.35**	**2.45**	**5.58**	**5.15**
.	**SD**	**1.100**	**0.223**	**0.391**	**2.193**	**1.930**	**0.407**	**1.456**	**0.208**	**0.478**	**2.077**	**2.986**	**0.754**
	SEM	**0.449**	**0.091**	**0.175**	**0.895**	**0.788**	**0.204**	**0.594**	**0.085**	**0.214**	**0.848**	**1.219**	**0.377**

Baseline Arm Ergometry Data

		WR (Watts)			HR (bpm)			SBP (mmHg)			DBP (mmHg)			ARPE			TRPE		
	Subject	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Exercise	1	0	0	2.5	.	83	96	.	78	84	.	55	60	.	3	4	.	3	3
Group	2	35	55	60	95	102	117	120	127	116	65	56	46	1	3	7	1	3	7
	4	1	6	10	112	118	126	86	75	82	52	60	56	3	4.5	5	2	3	3
	5	0	3	6	98	105	120	105	100	116	62	58	61	4.5	4	5.5	3	2.5	3.5
	6	15	35	45	97	99	101	146	105	110	88	80	85	3.5	6	6	1	6	5
	12	15	40	75	86	97	132	154	152	168	82	84	80	0	0.5	2	0	0.5	2
	13	15	25	35	131	148	161	84	88	95	55	62	69	2	4	6	3	4	7
	14	2.5	10	15	121	138	153	123	113	108	65	69	59	3	3	6	3	3	6
Control	3	2.5	6	10	82	85	92	77	81	70	53	52	48	4	2	5.5	5	3	7
Group	7	35	60	65	110	143	177	142	160	182	60	60	60	2	4	7	1	4.5	8
	8	25	40	45	105	146	158	150	158	162	76	80	67	1.5	3	7	1	3	7
	9	35	45	50	100	110	116	160	145	162	98	100	110	4	5.5	7.5	2	2	2
	10	2.5	17	25	100	114	132	108	124	131	70	71	52	2.5	3	4	0	2.5	3
	11	10	15	20	80	83	86	122	122	124	85	80	74	4.5	6	6	3	3	4

Post-Test Arm Ergometry Data

		WR (Watts)			HR (bpm)			SBP (mmHg)			DBP (mmHg)			ARPE			TRPE		
	Subject	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Exercise	1	2	5	7	84	101	105	94	88	98	60	56	64	1	2	3	3	8	7
Group	2	55	60	65	115	132	136	106	82	80	72	60	64	3	5	9	1	2	5
	4	10	6	22	112	96	121	70	86	72	56	64	58	7	4	10	10	4	8
	5	6	10	15	90	108	156	110	.	126	60	.	76	3	3.5	7	3	3.5	8
	6	45	.	.	103	.	.	110	.	.	85	.	.	7	.	.	8	.	.
	12	40	75	85	92	112	130	140	160	192	94	108	90	0	1	2	0	1	3
	13	35	45	55	151	159	160	98	82	90	70	66	70	3.5	5	6	2	4.5	5
	14	10	15	20	150	156	158	116	110	116	75	72	74	2.5	3	4.5	2	2.5	4
								.	.	.	.	.	.	.	.	.	.	.	.
Control	3	2.5	6	10	78	86	100	70	80	80	56	62	60	3	3	8	7	6	4
Group	7	35	60	65	103	135	172	154	160	178	84	90	80	1	3	5	2	4	7
	8	25	40	45	95	123	126	140	150	160	76	76	76	1	2	2.5	1	1.5	3
	9	35	45	50	94	103	109	150	154	154	90	90	92	5	6	7	2	3	3
	10	2.5	17	25	95	107	127	122	120	132	80	78	80	2.5	2.8	3	1	2	3
	11	10	15	20	77	78	80	120	110	122	78	79	78	4	6	7	2	4	6

Resting Cardiovascular Measures

		Pre			Post		
	Subject	HR (bpm)	SBP (mmHg)	DBP (mmHg)	HR (bpm)	SBP (mmHg)	DBP (mmHg)
Exercise	1	64	75	58	68	80	60
Group	2	74	116	64	76	112	82
	4	86	94	60	91	94	70
	5	78	104	67	64	118	70
	6	60	119	60	63	135	90
	12	62	158	95	71	120	86
	13	112	87	60	109	86	58
	14	84	106	66	.	106	74
	Mean	**77.5**	**107.38**	**66.25**	**77.43**	**106.38**	**73.75**
	SD	**17.096**	**25.151**	**12.056**	**16.841**	**18.654**	**11.634**
	SEM	**6.044**	**8.892**	**4.263**	**5.954**	**6.595**	**4.113**
Control	3	72	85	49	65	78	55
Group	7	80	132	70	73	142	85
	8	76	129	85	64	120	80
	9	68	170	110	64	140	98
	10	90	.	.	72	110	75
.	11	71	120	80	70	118	82
.	**Mean**	**76.17**	**127.20**	**78.80**	**68.00**	**118.00**	**79.17**
.	**SD**	**7.960**	**30.376**	**22.242**	**4.147**	**23.358**	**14.134**
	SEM	**3.250**	**13.585**	**9.947**	**1.693**	**9.536**	**5.770**

Pre-Post Percentage Difference in Resting Cardiovascular Measures (%)

	Subject	SBP (mmHg)	DBP (mmHg)	HR (bpm)
Exercise Group	1	6.666667	3.448276	6.25
	2	-3.448276	28.125	2.7
	4	0	16.666667	5.81
	5	13.461538	4.477612	-17.95
	6	13.445378	50	5
	12	-24.050633	-9.473684	14.52
	13	-1.149425	-3.333333	-2.68
	14	0	12.121212	.
	Mean	**0.615656125**	**12.75396875**	**1.95**
	SD	**11.923**	**19.076**	**10.155**
	SEM	**4.215**	**6.744**	**3.838**
Control Group	3	-8.235294	12.244898	-9.72
	7	7.575758	21.428571	-8.75
	8	-6.976744	-5.882353	-15.79
	9	-17.647059	-10.909091	-5.88
	10	.	.	-20
.	11	-1.666667	2.5	-1.41
.	**Mean**	**-5.39**	**3.88**	**-10.26**
.	**SD**	**9.258**	**13.171**	**6.716**
	SEM	**4.140**	**5.890**	**2.742**

Cardiovascular Measures Obtained During Exercise at Identical Workloads Within Subjects

		Pre			Post		
	Subject	HR (bpm)	SBP (mmHg)	DBP (mmHg)	HR (bpm)	SBP (mmHg)	DBP (mmHg)
Exercise	1	96	84	60	84	94	60
Group	2	117	116	46	132	82	60
	4	.	.	.	.	.	.
	5	120	116	61	90	.	.
	6	.	.	.	.	.	.
	12	132	168	80	112	160	108
	13	161	95	69	151	98	70
	14	153	108	59	156	110	72
	Mean	**129.83**	**114.5**	**62.50**	**120.83**	**108.80**	**74.00**
	SD	**24.161**	**29.050**	**11.327**	**30.518**	**30.318**	**19.799**
	SEM	**9.864**	**11.860**	**4.624**	**12.459**	**13.559**	**8.854**
Control	3	92	70	48	100	70	56
Group	7	177	182	60	172	154	84
	8	158	162	67	126	140	76
	9	116	162	110	109	150	90
	10	132	131	52	127	122	80
.	11	86	124	74	80	120	78
.	**Mean**	**126.83**	**138.50**	**68.50**	**119.00**	**126.00**	**77.33**
.	**SD**	**36.091**	**39.889**	**22.448**	**31.318**	**30.803**	**11.570**
	SEM	**14.734**	**16.284**	**9.164**	**12.785**	**12.575**	**4.723**

re-Post Percentage Difference in Ratings of Perceived Exertion for Arms (ARPE) and Total Body (TRPE) and Cardiovascular Variables (%)

	Subject	ARPE	TRPE	SBP (mmHg)	DBP (mmHg	HR (bpm)
Exercise	1	-75	0	11.904762	0	-12.5
Group	2	-28.571	-71.429	-29.310345	30.434783	12.82051
	4	.	.	.	.	.
	5	-45.455	-28.571	.	.	-25
	6	.	.	.	.	.
	12	-50	-50	-4.761905	35	-15.1515
	13	-41.667	-71.429	3.157895	1.449275	-6.21118
	14	-50	-58.333	1.851852	22.033898	1.960784
	Mean	**-48.45**	**-46.627**	**-3.4315482**	**17.7835912**	**-7.3469**
	SD	**15.231**	**27.852**	**15.637**	**16.260**	**13.370**
	SEM	**6.218**	**11.371**	**6.993**	**7.272**	**5.458**
Control	3	45.4545	-42.857	0	16.666667	8.695652
Group	7	-28.571	-12.5	-15.384615	40	-2.82486
	8	-64.286	-57.143	-13.580247	13.432836	-20.2532
	9	-6.6667	50	-7.407407	-18.181818	-6.03448
	10	-25	0	-6.870229	53.846154	-3.78788
.	11	16.6667	50	-3.225806	5.405405	-6.97674
.	**Mean**	**-10.40**	**-2.08**	**-7.74**	**18.53**	**-5.20**
.	**SD**	**38.245**	**45.238**	**5.894**	**25.525**	**9.286**
	SEM	**15.613**	**18.468**	**2.406**	**10.421**	**3.791**

Pre-Post Percentage Difference in Ratings of Perceived Exertion for Arms (ARPE) and Total Body (TRPE) and Cardiovascular Variables (%)

	Subject	ARPE	TRPE	SBP (mmHg)	DBP (mmHg	HR (bpm)
Exercise	1	-75	0	11.904762	0	-12.5
Group	2	-28.571	-71.429	-29.310345	30.434783	12.82051
	4	.	.	.	.	.
	5	-45.455	-28.571	.	.	-25
	6	.	.	.	.	.
	12	-50	-50	-4.761905	35	-15.1515
	13	-41.667	-71.429	3.157895	1.449275	-6.21118
	14	-50	-58.333	1.851852	22.033898	1.960784
	Mean	**-48.45**	**-46.627**	**-3.4315482**	**17.7835912**	**-7.3469**
	SD	**15.231**	**27.852**	**15.637**	**16.260**	**13.370**
	SEM	**6.218**	**11.371**	**6.993**	**7.272**	**5.458**
Control	3	45.4545	-42.857	0	16.666667	8.695652
Group	7	-28.571	-12.5	-15.384615	40	-2.82486
	8	-64.286	-57.143	-13.580247	13.432836	-20.2532
	9	-6.6667	50	-7.407407	-18.181818	-6.03448
	10	-25	0	-6.870229	53.846154	-3.78788
.	11	16.6667	50	-3.225806	5.405405	-6.97674
.	**Mean**	**-10.40**	**-2.08**	**-7.74**	**18.53**	**-5.20**
.	**SD**	**38.245**	**45.238**	**5.894**	**25.525**	**9.286**
	SEM	**15.613**	**18.468**	**2.406**	**10.421**	**3.791**

Bodily Pain (SF-36) Scores

	Subject	Pre	Post
Exercise Group	1	5	5
	2	1	1
	4	1	2
	5	3	2
	6	2	2
	12	3	2
	13	4	3
	14	2	5
	Mean	**2.63**	**2.75**
	SD	**1.408**	**1.488**
Control Group	3	4	5
	7	2	2
	8	2	3
	9	1	6
	10	5	4
.	11	4	4
.	**Mean**	**3.00**	**4.00**
.	**SD**	**1.549**	**1.414**

Cantril's Ladder of Life Satisfaction

	Subject	Pre	Post
Exercise Group	1	6	6
	2	6	4
	4	5	1
	5	5	6
	6	7	5
	12	5	7
	13	5	5
	14	7	7
	Mean	**5.75**	**5.13**
	SD	**0.886**	**1.959**
Control Group	3	7	3
	7	6	7
	8	6	7
	9	5	5
	10	4	4
	11	5	4
	Mean	**5.50**	**5.00**
	SD	**1.049**	**1.673**

Perceived Stress Scale - Pre

	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SUM
xercise	1	5	4	6	3	3	2	5	4	3	3	4	5	3	2	52
Group	2	1	1	1	1	2	1	3	1	2	2	2	2	1	1	21
	4	2	2	3	2	5	2	3	3	2	2	2	6	2	2	38
	5	3	5	4	3	4	2	4	4	4	4	2	5	3	3	50
	6	3	2	3	2	3	2	2	1	2	3	3	3	3	1	33
	12	2	1	2	2	5	1	2	1	1	1	2	1	1	1	23
	13	2	2	3	2	4	2	3	2	4	2	2	5	3	1	37
	14	2	1	2	2	2	2	3	3	2	3	2	3	3	2	32
	Mean	**2.5**	**2.25**	**3.00**	**2.13**	**3.50**	**1.75**	**3.13**	**2.38**	**2.50**	**2.50**	**2.38**	**3.75**	**2.38**	**1.63**	**35.75**
	SD	**1.195**	**1.488**	**1.512**	**0.641**	**1.195**	**0.463**	**0.991**	**1.302**	**1.069**	**0.926**	**0.744**	**1.753**	**0.916**	**0.744**	**11.184**
Control	3	2	4	3	2	2	2	3	2	2	2	3	5	4	2	38
Group	7	2	4	1	1	2	1	2	1	1	2	3	4	1	2	27
	8	2	4	4	3	3	4	5	3	4	5	4	4	3	4	52
	9	3	4	4	3	4	4	4	3	4	4	2	2	4	3	48
	10	3	2	3	3	4	4	4	3	4	4	2	3	2	4	45
.	11	3	4	2	3	4	3	3	2	5	4	2	3	2	2	42
.	**Mean**	**2.50**	**3.67**	**2.83**	**2.50**	**3.17**	**3.00**	**3.50**	**2.33**	**3.33**	**3.50**	**2.67**	**3.50**	**2.67**	**2.83**	**42.00**
.	**SD**	**0.548**	**0.816**	**1.169**	**0.837**	**0.983**	**1.265**	**1.049**	**0.816**	**1.506**	**1.225**	**0.816**	**1.049**	**1.211**	**0.983**	**8.786**

Perceived Stress Scale - Post

	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SUM
Exercise	1	5	3	2	3	2	2	4	2	2	2	2	5	4	3	43
Group	2	2	2	1	1	1	1	4	1	1	1	1	2	4	1	23
	4	2	1	3	1	2	2	2	2	2	2	2	6	2	2	35
	5	1	2	1	4	4	4	4	3	2	3	2	6	5	2	43
	6	1	1	1	2	4	5	4	1	2	2	2	2	2	1	27
	12	1	1	1	1	5	1	2	1	1	2	1	2	1	1	21
	13	2	3	2	4	5	3	4	2	2	3	3	4	2	1	38
	14	3	2	2	2	3	2	2	3	2	2	2	3	3	3	34
	Mean	**2.13**	**1.88**	**1.63**	**2.25**	**3.25**	**2.50**	**3.25**	**1.88**	**1.75**	**2.13**	**1.88**	**3.75**	**2.88**	**1.75**	**33.00**
	SD	**1.356**	**0.835**	**0.744**	**1.282**	**1.488**	**1.414**	**1.035**	**0.835**	**0.463**	**0.641**	**0.641**	**1.753**	**1.356**	**0.886**	**8.536**
Control	3	4	3	4	2	5	4	4	4	4	4	3	4	5	3	49
Group	7	3	2	2	1	2	2	2	1	2	2	2	4	1	1	27
	8	2	2	2	2	3	4	4	2	4	4	3	3	4	2	42
	9	3	3	4	3	3	3	5	3	4	5	3	2	4	2	47
	10	2	2	3	3	5	5	5	2	5	5	2	4	5	3	49
.	11	2	3	2	2	5	4	3	2	2	3	2	4	3	2	38
.	**Mean**	**2.67**	**2.50**	**2.83**	**2.17**	**3.83**	**3.67**	**3.83**	**2.33**	**3.50**	**3.83**	**2.50**	**3.50**	**3.67**	**2.17**	**42.00**
.	**SD**	**0.816**	**0.548**	**0.983**	**0.753**	**1.329**	**1.033**	**1.169**	**1.033**	**1.225**	**1.169**	**0.548**	**0.837**	**1.506**	**0.753**	**8.532**

Perceived Stress Scale - Post

	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SUM
Exercise	1	5	3	2	3	2	2	4	2	2	2	2	5	4	3	43
Group	2	2	2	1	1	1	1	4	1	1	1	1	2	4	1	23
	4	2	1	3	1	2	2	2	2	2	2	2	6	2	2	35
	5	1	2	1	4	4	4	4	3	2	3	2	6	5	2	43
	6	1	1	1	2	4	5	4	1	2	2	2	2	2	1	27
	12	1	1	1	1	5	1	2	1	1	2	1	2	1	1	21
	13	2	3	2	4	5	3	4	2	2	3	3	4	2	1	38
	14	3	2	2	2	3	2	2	3	2	2	2	3	3	3	34
	Mean	**2.13**	**1.88**	**1.63**	**2.25**	**3.25**	**2.50**	**3.25**	**1.88**	**1.75**	**2.13**	**1.88**	**3.75**	**2.88**	**1.75**	**33.00**
	SD	**1.356**	**0.835**	**0.744**	**1.282**	**1.488**	**1.414**	**1.035**	**0.835**	**0.463**	**0.641**	**0.641**	**1.753**	**1.356**	**0.886**	**8.536**
Control	3	4	3	4	2	5	4	4	4	4	4	3	4	5	3	49
Group	7	3	2	2	1	2	2	2	1	2	2	2	4	1	1	27
	8	2	2	2	2	3	4	4	2	4	4	3	3	4	2	42
	9	3	3	4	3	3	3	5	3	4	5	3	2	4	2	47
	10	2	2	3	3	5	5	5	2	5	5	2	4	5	3	49
.	11	2	3	2	2	5	4	3	2	2	3	2	4	3	2	38
.	**Mean**	**2.67**	**2.50**	**2.83**	**2.17**	**3.83**	**3.67**	**3.83**	**2.33**	**3.50**	**3.83**	**2.50**	**3.50**	**3.67**	**2.17**	**42.00**
.	**SD**	**0.816**	**0.548**	**0.983**	**0.753**	**1.329**	**1.033**	**1.169**	**1.033**	**1.225**	**1.169**	**0.548**	**0.837**	**1.506**	**0.753**	**8.532**

Exercise Induced Feelings Inventory Scores - Post

	Subject	1	2	3	4	5	6	7	8	9	10	11	12	POSITIVE	NEGATIVE
rcise	1	4	4	5	4	5	4	4	4	5	5	4	4	39	13
oup	2	4	1	5	4	2	4	2	4	4	2	5	2	25	14
	4	5	5	2	4	5	2	3	2	5	5	2	3	37	6
	5	5	4	2	4	3	4	3	3	4	3	4	2	32	9
	6	6	2	5	2	3	3	2	5	3	4	6	2	27	16
	12	2	2	6	2	2	2	2	6	2	2	6	2	18	18
	13	4	3	5	4	4	4	2	5	6	5	4	5	37	14
	14	2	2	5	2	2	2	2	5	2	2	5	2	18	15
	Mean	**4**	**2.88**	**4.38**	**3.25**	**3.25**	**3.13**	**2.50**	**4.25**	**3.88**	**3.50**	**4.50**	**2.75**	**29.13**	**13.13**
	SD	**1.414**	**1.356**	**1.506**	**1.035**	**1.282**	**0.991**	**0.756**	**1.282**	**1.458**	**1.414**	**1.309**	**1.165**	**8.442**	**3.871**
ntrol	3	3	3	2	5	5	4	3	3	4	3	3	2	32	8
oup	7	2	2	5	2	2	2	2	5	2	2	5	2	18	15
	8	5	3	5	4	4	5	4	4	5	3	5	4	37	14
	9	5	5	5	6	5	5	5	5	5	5	5	5	46	15
	10	5	5	3	4	5	5	4	3	5	4	3	5	42	9
.	11	4	3	4	4	3	4	2	5	4	4	4	4	32	13
.	**Mean**	**4.00**	**3.50**	**4.00**	**4.17**	**4.00**	**4.17**	**3.33**	**4.17**	**4.17**	**3.50**	**4.17**	**3.67**	**34.50**	**12.33**
.	**SD**	**1.265**	**1.225**	**1.265**	**1.329**	**1.265**	**1.169**	**1.211**	**0.983**	**1.169**	**1.049**	**0.983**	**1.366**	**9.793**	**3.077**

Centre For Epidemiological Studies Depression Scale Scores - Pre

	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	SCORE
rcise	1	2	2	1	0	1	2	1	0	0	0	1	2	2	0	0	1	0	0	0	1	14
oup	2	0	1	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4
	4	1	0	0	0	0	1	2	0	0	0	1	1	0	1	0	1	0	0	0	0	7
	5	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	0	0	1	5
	6	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2
	12	0	0	0	3	0	1	0	0	3	0	1	0	0	0	1	0	0	0	0	0	9
	13	1	1	0	0	2	1	1	1	0	2	3	1	1	1	0	1	0	1	0	0	16
	14	0	0	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	6
	Mean	**0.5**	**0.50**	**0.25**	**0.38**	**0.63**	**0.63**	**0.63**	**0.25**	**0.38**	**0.25**	**1.38**	**0.50**	**0.63**	**0.38**	**0.13**	**0.38**	**0.00**	**0.25**	**0.00**	**0.38**	**7.88**
	SD	**0.756**	**0.756**	**0.463**	**1.061**	**0.916**	**0.744**	**0.744**	**0.463**	**1.061**	**0.707**	**0.916**	**0.756**	**0.744**	**0.518**	**0.354**	**0.518**	**0.000**	**0.463**	**0.000**	**0.518**	**4.883**
ntrol	3	1	0	0	0	1	0	2	1	0	0	0	1	1	1	0	0	0	0	0	0	7
oup	7	0	1	0	0	0	0	3	0	0	0	1	1	1	0	0	0	0	0	0	0	7
	8	1	0	2	2	1	1	1	2	1	2	1	2	1	1	1	2	1	2	1	0	24
	9	2	1	2	1	1	1	1	2	1	1	2	2	1	1	0	1	0	1	0	1	20
	10	1	0	2	1	2	2	1	2	1	0	1	1	1	2	0	1	0	1	0	1	19
.	11	1	0	0	0	1	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	6
.	**Mean**	**1.00**	**0.33**	**1.00**	**0.67**	**1.00**	**0.67**	**1.50**	**1.33**	**0.50**	**0.67**	**1.00**	**1.33**	**0.83**	**0.83**	**0.17**	**0.67**	**0.17**	**0.67**	**0.17**	**0.33**	**13.83**
.	**SD**	**0.632**	**0.516**	**1.095**	**0.816**	**0.632**	**0.816**	**0.837**	**0.816**	**0.548**	**0.816**	**0.632**	**0.516**	**0.408**	**0.753**	**0.408**	**0.816**	**0.408**	**0.816**	**0.408**	**0.516**	**8.035**

Centre For Epidemiological Studies Depression Scale Scores - Pre

	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	SCORE
cis																						
	1	2	2	1	0	1	2	1	0	0	0	1	2	2	0	0	1	0	0	0	1	14
up	2	0	1	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4
	4	1	0	0	0	0	1	2	0	0	0	1	1	0	1	0	1	0	0	0	0	7
	5	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	0	0	1	5
	6	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2
	12	0	0	0	3	0	1	0	0	3	0	1	0	0	0	1	0	0	0	0	0	9
	13	1	1	0	0	2	1	1	1	0	2	3	1	1	1	0	1	0	1	0	0	16
	14	0	0	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	6
	Mean	**0.5**	**0.50**	**0.25**	**0.38**	**0.63**	**0.63**	**0.63**	**0.25**	**0.38**	**0.25**	**1.38**	**0.50**	**0.63**	**0.38**	**0.13**	**0.38**	**0.00**	**0.25**	**0.00**	**0.38**	**7.88**
	SD	**0.756**	**0.756**	**0.463**	**1.061**	**0.916**	**0.744**	**0.744**	**0.463**	**1.061**	**0.707**	**0.916**	**0.756**	**0.744**	**0.518**	**0.354**	**0.518**	**0.000**	**0.463**	**0.000**	**0.518**	**4.883**
trol	3	1	0	0	0	1	0	2	1	0	0	0	1	1	1	0	0	0	0	0	0	7
up	7	0	1	0	0	0	0	3	0	0	0	1	1	1	0	0	0	0	0	0	0	7
	8	1	0	2	2	1	1	1	2	1	2	1	2	1	1	1	2	1	2	1	0	24
	9	2	1	2	1	1	1	1	2	1	1	2	2	1	1	0	1	0	1	0	1	20
	10	1	0	2	1	2	2	1	2	1	0	1	1	1	2	0	1	0	1	0	1	19
	11	1	0	0	0	1	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	6
	Mean	**1.00**	**0.33**	**1.00**	**0.67**	**1.00**	**0.67**	**1.50**	**1.33**	**0.50**	**0.67**	**1.00**	**1.33**	**0.83**	**0.83**	**0.17**	**0.67**	**0.17**	**0.67**	**0.17**	**0.33**	**13.83**
	SD	**0.632**	**0.516**	**1.095**	**0.816**	**0.632**	**0.816**	**0.837**	**0.816**	**0.548**	**0.816**	**0.632**	**0.516**	**0.408**	**0.753**	**0.408**	**0.816**	**0.408**	**0.816**	**0.408**	**0.516**	**8.035**

Beliefs Scale - Perceived Control Questions

		Pre				Post			
	Subject	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Exercise	1	4	4	4	4	4	5	5	5
Group	2	5	5	5	5	5	5	5	5
	4	3	4	3	4	4	3	2	4
	5	4	4	3	5	2	5	5	5
	6	5	5	4	5	4	5	4	5
	12	5	5	4	5	5	5	5	5
	13	3	3	3	4	3	3	4	4
	14	4	4	4	5	4	5	5	5
	Mean	**4.125**	**4.25**	**3.75**	**4.63**	**3.88**	**4.50**	**4.38**	**4.75**
	SD	**0.835**	**0.707**	**0.707**	**0.518**	**0.991**	**0.926**	**1.061**	**0.463**
Control	3	4	4	4	4	4	4	4	4
Group	7	5	5	4	4	4	5	4	4
	8	4	4	4	5	4	4	4	3
	9	2	3	4	4	3	3	4	5
	10	3	3	3	4	3	3	3	4
.	11	4	3	3	4	4	4	4	4
.	**Mean**	**3.67**	**3.67**	**3.67**	**4.17**	**3.67**	**3.83**	**3.83**	**4.00**
.	**SD**	**1.033**	**0.816**	**0.516**	**0.408**	**0.516**	**0.753**	**0.408**	**0.632**

One Repetition Maximums for Chest Press, Elbow Flexion and Shoulder Flexion (lbs)

		Pre						Post					
	Subject	R Chest	L Chest	R Elbow	L Elbow	R Shoulder	L Shoulder	R Chest	L Chest	R Elbow	L Elbow	R Shoulder	L Shoulder
cise	1	8.7	10	31.25	31.25	8	11	13	13	32.5	32.5	12.5	14.5
up	2	52	52.85	.	42.5	25	23	53.7	55	55	45	28	25
	4	20.7	14.7	57.5	47.5	25	20	20.7	14.7	47.5	37.5	24	17.5
	5	13.85	13	27.5	32.5	7.5	6	11.7	10	35	35	7.5	9
	6	49	49	37.5	33.75	26	30	52	50.7	45	42.5	30	29
	12	46	34	40	35	17.5	15	40	40	40	37.5	.	.
	13	38.7	34	33.75	35	14.5	17.5	40	40	40	35	19	19
	14	12.56	11.7	15	17.5	6	6.5	14.7	10.85	17.5	20	10	7.5
	Mean	**30.1888**	**27.41**	**34.64**	**34.38**	**16.19**	**16.13**	**30.725**	**29.28**	**39.06**	**35.63**	**18.71**	**17.36**
	SD	**18.054**	**17.400**	**12.965**	**8.763**	**8.472**	**8.275**	**17.671**	**19.046**	**11.255**	**7.530**	**8.962**	**7.872**
	SEM	**6.383**	**6.152**	**4.900**	**3.098**	**2.995**	**2.926**	**6.248**	**6.734**	**3.979**	**2.662**	**3.387**	**2.976**
trol	3	13.85	16	32.5	35	15	15	13	14.7	37.5	32.5	15	11
up	7	52	52	47.5	47.5	27	30	65.7	58	52.5	47.5	35	40
	8	32.7	34	25	25	16.5	14.5	33.56	32.7	17.5	17.5	15	12.5
	9	31	31	27.5	25	20	18.5	34	29.7	25	25	17.5	17
	10	17.5	17.7	27.5	25	10	6	16	16	20	15	10	7.5
	11	31	31	25	18.75	15	15	25	25	25	18.75	15	12.5
	Mean	**29.68**	**30.28**	**30.83**	**29.38**	**17.25**	**16.50**	**31.21**	**29.35**	**29.58**	**26.04**	**17.92**	**16.75**
	SD	**13.489**	**13.029**	**8.612**	**10.300**	**5.760**	**7.810**	**18.997**	**15.773**	**13.174**	**12.258**	**8.720**	**11.793**
	SEM	**5.507**	**5.319**	**3.516**	**4.205**	**2.351**	**3.189**	**7.755**	**6.439**	**5.378**	**5.004**	**3.560**	**4.814**

Change in One Repetition Maximums (%)

	Subject	R Chest	L Chest	R Elbow	L Elbow	R Shoulder	L Shoulder
Exercise	1	49.43	30	4	4	56.25	31.82
Group	2	3.27	4.07	.	5.88	12	8.7
	4	0	0	-17.39	-21.05	-4	-12.5
	5	-15.52	-23.08	27.27	7.69	0	50
	6	6.12	3.47	20	25.93	15.38	-3.33
	12	-13.04	17.65	0	7.14	.	.
	13	3.36	17.65	18.52	0	31.03	8.57
	14	17.04	-7.26	16.67	14.29	66.67	15.38
	Mean	**6.3325**	**5.31**	**9.87**	**5.49**	**25.33**	**14.09**
	SD	**20.295**	**16.524**	**15.283**	**13.308**	**27.313**	**21.117**
	SEM	**7.175**	**5.842**	**5.776**	**4.705**	**10.323**	**7.981**
Control	3	-6.14	-8.13	15.38	-7.14	0	-26.67
Group	7	26.35	11.54	10.53	0	29.63	33.33
	8	2.63	-3.82	-30	-30	-9.09	-13.79
	9	9.68	-4.19	-9.09	0	-12.5	-8.11
	10	-8.57	-9.6	-27.27	-40	0	25
.	11	-19.35	-19.35	0	0	0	-16.67
.	**Mean**	**0.77**	**-5.59**	**-6.74**	**-12.86**	**1.34**	**-1.15**
.	**SD**	**15.981**	**10.103**	**18.979**	**17.659**	**14.873**	**24.385**
	SEM	**6.524**	**4.125**	**7.748**	**7.209**	**6.072**	**9.955**

Change in One Repetition Maximums (%)

	Subject	R Chest	L Chest	R Elbow	L Elbow	R Shoulder	L Shoulder
Exercise	1	49.43	30	4	4	56.25	31.82
Group	2	3.27	4.07	.	5.88	12	8.7
	4	0	0	-17.39	-21.05	-4	-12.5
	5	-15.52	-23.08	27.27	7.69	0	50
	6	6.12	3.47	20	25.93	15.38	-3.33
	12	-13.04	17.65	0	7.14	.	.
	13	3.36	17.65	18.52	0	31.03	8.57
	14	17.04	-7.26	16.67	14.29	66.67	15.38
	Mean	**6.3325**	**5.31**	**9.87**	**5.49**	**25.33**	**14.09**
	SD	**20.295**	**16.524**	**15.283**	**13.308**	**27.313**	**21.117**
	SEM	**7.175**	**5.842**	**5.776**	**4.705**	**10.323**	**7.981**
Control	3	-6.14	-8.13	15.38	-7.14	0	-26.67
Group	7	26.35	11.54	10.53	0	29.63	33.33
	8	2.63	-3.82	-30	-30	-9.09	-13.79
	9	9.68	-4.19	-9.09	0	-12.5	-8.11
	10	-8.57	-9.6	-27.27	-40	0	25
.	11	-19.35	-19.35	0	0	0	-16.67
.	**Mean**	**0.77**	**-5.59**	**-6.74**	**-12.86**	**1.34**	**-1.15**
.	**SD**	**15.981**	**10.103**	**18.979**	**17.659**	**14.873**	**24.385**
	SEM	**6.524**	**4.125**	**7.748**	**7.209**	**6.072**	**9.955**

Summed One Repetition Maximums For Chest Press, Elbow Flexion and Shoulder Flexion (lbs)

		Pre			Post		
	Subject	Chest	Elbow	Shoulder	Chest	Elbow	Shoulder
Exercise	1	18.7	62.5	19	26	65	27
Group	2	104.85	.	48	108.7	100	53
	4	35.4	105	45	35.4	85	41.5
	5	26.85	60	13.5	21.7	70	16.5
	6	98	71.25	56	102.7	87.5	59
	12	80	75	32.5	80	77.5	.
	13	72.7	68.75	32	80	75	38
	14	24.26	32.5	12.5	25.55	37.5	17.5
	Mean	**57.595**	**67.86**	**32.31**	**60.01**	**74.69**	**36.07**
	SD	**35.168**	**21.539**	**16.440**	**36.664**	**18.586**	**16.612**
	SEM	**12.434**	**8.141**	**5.813**	**12.963**	**6.571**	**6.279**
Control	3	29.85	67.5	30	27.7	70	26
Group	7	104	95	57	123.7	100	75
	8	66.7	50	31	66.26	35	27.5
	9	62	52.5	38.5	63.7	50	34.5
	10	35.2	52.5	16	32	35	17.5
.	11	62	43.75	30	50	43.75	27.5
.	**Mean**	**59.96**	**60.21**	**33.75**	**60.56**	**55.63**	**34.67**
.	**SD**	**26.506**	**18.749**	**13.519**	**34.745**	**25.295**	**20.491**
	SEM	**10.821**	**7.654**	**5.519**	**14.184**	**10.327**	**8.365**

Mean Percentage Change in One Repetition Maximums for Chest Press, Elbow Flexion and Shoulder Flexion (%)

	Subject	Chest	Elbow	Shoulder
Exercise Group	1	49.43	4	44.05
	2	3.67	5.88	10.35
	4	0	-19.22	-8.25
	5	-19.3	17.48	50
	6	4.8	22.97	6.03
	12	2.31	7.14	.
	13	10.51	18.52	19.8
	14	4.89	.	41.03
	Mean	**7.03875**	**8.11**	**23.29**
	SD	**19.256**	**14.064**	**22.104**
	SEM	**6.808**	**5.316**	**8.354**
Control Group	3	-7.14	4.12	-26.67
	7	18.95	10.53	31.48
	8	-0.6	-30	-11.44
	9	2.75	-9.09	-10.31
	10	-9.09	33.64	25
.	11	-19.35	0	-16.67
.	**Mean**	**-2.41**	**1.53**	**-1.44**
.	**SD**	**12.962**	**21.109**	**23.791**
	SEM	**5.292**	**8.618**	**9.713**

APPENDIX C: STATISTICAL TABLES

Triglycerides

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	6.602E-02	1	6.602E-02	.106	.751
TIME * GROUP	Linear	4.597E-02	1	4.597E-02	.074	.791
Error(TIME)	Linear	7.499	12	.625		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	135.293	1	135.293	27.629	.000
GROUP	2.705	1	2.705	.552	.472
Error	58.761	12	4.897		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DTG

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	178.577	1	178.577	.060	.811
Intercept	612.257	1	612.257	.206	.658
GROUP	178.577	1	178.577	.060	.811
Error	35738.312	12	2978.193		
Total	36449.179	14			
Corrected Total	35916.888	13			

a R Squared = .005 (Adjusted R Squared = -.078)

Total Cholesterol

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	.270	1	.270	.993	.339
TIME * GROUP	Linear	.104	1	.104	.384	.547
Error(TIME)	Linear	3.260	12	.272		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	619.943	1	619.943	216.891	.000
GROUP	1.288E-02	1	1.288E-02	.005	.948
Error	34.300	12	2.858		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DTC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	50.297	1	50.297	.242	.632
Intercept	243.409	1	243.409	1.171	.301
GROUP	50.297	1	50.297	.242	.632
Error	2495.395	12	207.950		
Total	2762.948	14			
Corrected Total	2545.693	13			

a R Squared = .020 (Adjusted R Squared = -.062)

TC/HDL Ratio

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	3.182	1	3.182	4.059	.067
TIME * GROUP	Linear	2.411E-03	1	2.411E-03	.003	.957
Error(TIME)	Linear	9.409	12	.784		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	756.300	1	756.300	58.452	.000
GROUP	8.601E-03	1	8.601E-03	.001	.980
Error	155.266	12	12.939		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects
Dependent Variable: DRATIO

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.315	1	4.315	.011	.919
Intercept	2300.598	1	2300.598	5.728	.034
GROUP	4.315	1	4.315	.011	.919
Error	4820.066	12	401.672		
Total	7143.937	14			
Corrected Total	4824.381	13			

a R Squared = .001 (Adjusted R Squared = -.082)

Low-Density Lipoproteins

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	4.631E-02	1	4.631E-02	.513	.489
TIME * GROUP	Linear	.176	1	.176	1.954	.190
Error(TIME)	Linear	.992	11	9.022E-02		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	171.235	1	171.235	107.931	.000
GROUP	.611	1	.611	.385	.548
Error	17.452	11	1.587		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DLDL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	401.200	1	401.200	1.398	.262
Intercept	157.598	1	157.598	.549	.474
GROUP	401.200	1	401.200	1.398	.262
Error	3157.837	11	287.076		
Total	3625.485	13			
Corrected Total	3559.037	12			

a R Squared = .113 (Adjusted R Squared = .032)

High-Density Lipoproteins

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	.192	1	.192	43.497	.000
TIME * GROUP	Linear	3.857E-04	1	3.857E-04	.087	.773
Error(TIME)	Linear	5.308E-02	12	4.423E-03		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	28.876	1	28.876	131.967	.000
GROUP	3.400E-02	1	3.400E-02	.155	.700
Error	2.626	12	.219		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DHDL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	38.601	1	38.601	.661	.432
Intercept	2977.519	1	2977.519	50.969	.000
GROUP	38.601	1	38.601	.661	.432
Error	701.024	12	58.419		
Total	3681.099	14			
Corrected Total	739.625	13			

a R Squared = .052 (Adjusted R Squared = -.027)

Fasting Blood Glucose

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	9.967E-02	1	9.967E-02	.552	.482
TIME * GROUP	Linear	.192	1	.192	1.063	.337
Error(TIME)	Linear	1.264	7	.181		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	534.775	1	534.775	308.614	.000
GROUP	.446	1	.446	.257	.628
Error	12.130	7	1.733		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects
Dependent Variable: DGLUCOSE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	119.629	1	119.629	1.097	.330
Intercept	58.548	1	58.548	.537	.488
GROUP	119.629	1	119.629	1.097	.330
Error	763.412	7	109.059		
Total	924.986	9			
Corrected Total	883.041	8			

a R Squared = .135 (Adjusted R Squared = .012)

Arm Rating of Perceived Exertion

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	14.260	1	14.260	8.855	.014
TIME * GROUP	Linear	3.760	1	3.760	2.335	.157
Error (TIME)	Linear	16.104	10	1.610		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	565.510	1	565.510	121.561	.000
GROUP	21.094	1	21.094	4.534	.059
Error	46.521	10	4.652		

1-Way, between GROUP ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: delta arm rpe for pretest work rate 3 (%)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4343.029	1	4343.029	5.126	.047
Intercept	10389.687	1	10389.687	12.262	.006
GROUP	4343.029	1	4343.029	5.126	.047
Error	8473.155	10	847.315		
Total	23205.871	12			
Corrected Total	12816.184	11			

a R Squared = .339 (Adjusted R Squared = .273)

Total Body Rating of Perceived Exertion

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	17.510	1	17.510	6.861	.026
TIME * GROUP	Linear	4.594	1	4.594	1.800	.209
Error(TIME)	Linear	25.521	10	2.552		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	404.260	1	404.260	86.281	.000
GROUP	10.010	1	10.010	2.137	.175
Error	46.854	10	4.685		

1-Way, between GROUP ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DRPETOT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5952.410	1	5952.410	4.218	.067
Intercept	7118.085	1	7118.085	5.044	.049
GROUP	5952.410	1	5952.410	4.218	.067
Error	14110.981	10	1411.098		
Total	27181.477	12			
Corrected Total	20063.392	11			

a R Squared = .297 (Adjusted R Squared = .226)

Resting Systolic Blood Pressure

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	113.785	1	113.785	.902	.363
TIME * GROUP	Linear	67.015	1	67.015	.531	.481
Error(TIME)	Linear	1387.600	11	126.145		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	326317.388	1	326317.388	303.727	.000
GROUP	1680.465	1	1680.465	1.564	.237
Error	11818.150	11	1074.377		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: delta systolic bp at rest (%)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	110.978	1	110.978	.912	.360
Intercept	70.137	1	70.137	.577	.464
GROUP	110.978	1	110.978	.912	.360
Error	1337.871	11	121.625		
Total	1486.164	13			
Corrected Total	1448.849	12			

a R Squared = .077 (Adjusted R Squared = -.007)

Resting Diastolic Blood Pressure

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	116.446	1	116.446	1.751	.213
TIME * GROUP	Linear	61.062	1	61.062	.918	.358
Error(TIME)	Linear	731.400	11	66.491		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	137356.062	1	137356.062	360.566	.000
GROUP	543.754	1	543.754	1.427	.257
Error	4190.400	11	380.945		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DDBPREST

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	242.496	1	242.496	.823	.384
Intercept	850.983	1	850.983	2.888	.117
GROUP	242.496	1	242.496	.823	.384
Error	3241.058	11	294.642		
Total	4617.500	13			
Corrected Total	3483.554	12			

a R Squared = .070 (Adjusted R Squared = -.015)

Heart Rate During Rest

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	86.309	1	86.309	3.668	.082
TIME * GROUP	Linear	131.539	1	131.539	5.590	.038
Error(TIME)	Linear	258.845	11	23.531		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	143613.122	1	143613.122	411.026	.000
GROUP	156.199	1	156.199	.447	.518
Error	3843.417	11	349.402		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects
Dependent Variable: delta resting heart rate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.816E-02	1	4.816E-02	6.276	.029
Intercept	2.230E-02	1	2.230E-02	2.906	.116
GROUP	4.816E-02	1	4.816E-02	6.276	.029
Error	8.441E-02	11	7.674E-03		
Total	.150	13			
Corrected Total	.133	12			

a R Squared = .363 (Adjusted R Squared = .305)

Systolic Blood Pressure During Exercise

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	436.923	1	436.923	4.472	.064
TIME * GROUP	Linear	68.741	1	68.741	.704	.423
Error(TIME)	Linear	879.350	9	97.706		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	324076.705	1	324076.705	147.952	.000
GROUP	2348.523	1	2348.523	1.072	.327
Error	19713.750	9	2190.417		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects
Dependent Variable: delta systolic bp for pretest work rate 3 (%)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	50.737	1	50.737	.396	.545
Intercept	340.661	1	340.661	2.662	.137
GROUP	50.737	1	50.737	.396	.545
Error	1151.721	9	127.969		
Total	1570.482	11			
Corrected Total	1202.457	10			

a R Squared = .042 (Adjusted R Squared = -.064)

Diastolic Blood Pressure During Exercise

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	547.274	1	547.274	4.986	.052
TIME * GROUP	Linear	7.638	1	7.638	.070	.798
Error(TIME)	Linear	987.817	9	109.757		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	108929.456	1	108929.456	222.415	.000
GROUP	111.274	1	111.274	.227	.645
Error	4407.817	9	489.757		

1-Way between GROUP ANOVA examining percentage difference scores

Tests of Between-Subjects Effects
Dependent Variable: DDBPEX

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.512	1	1.512	.003	.956
Intercept	3596.036	1	3596.036	7.500	.023
GROUP	1.512	1	1.512	.003	.956
Error	4315.246	9	479.472		
Total	7956.293	11			
Corrected Total	4316.758	10			

a R Squared = .000 (Adjusted R Squared = -.111)

Heart Rate During Exercise

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	425.042	1	425.042	3.960	.075
TIME * GROUP	Linear	2.042	1	2.042	.019	.893
Error(TIME)	Linear	1073.417	10	107.342		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	369768.375	1	369768.375	206.355	.000
GROUP	35.042	1	35.042	.020	.892
Error	17919.083	10	1791.908		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: delta hr for pretest work rate 3 (%)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.867	1	13.867	.105	.753
Intercept	472.042	1	472.042	3.563	.088
GROUP	13.867	1	13.867	.105	.753
Error	1324.921	10	132.492		
Total	1810.830	12			
Corrected Total	1338.789	11			

a R Squared = .010 (Adjusted R Squared = -.089)

Perceived Stress

Between GROUP ANCOVA: post-test perceived stress score with baseline perceived stress score as the covariate.

Tests of Between-Subjects Effects

Dependent Variable: stress post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	887.408	2	443.704	18.466	.000	.771
Intercept	86.319	1	86.319	3.592	.085	.246
SUMSTRS1	609.694	1	609.694	25.375	.000	.698
GROUP	67.163	1	67.163	2.795	.123	.203
Error	264.306	11	24.028			
Total	20170.000	14				
Corrected Total	1151.714	13				

a R Squared = .771 (Adjusted R Squared = .729)

General Life Satisfaction

Between GROUP ANCOVA: post-test Cantril's ladder score with baseline Cantril's ladder score as the covariate.

Tests of Between-Subjects Effects

Dependent Variable: Cantril's Post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	1.696	2	.848	.238	.792	.041
Intercept	2.830	1	2.830	.794	.392	.067
Cantril's Pre	1.642	1	1.642	.460	.511	.040
GROUP	2.714E-03	1	2.714E-03	.001	.978	.000
Error	39.233	11	3.567			
Total	401.000	14				
Corrected Total	40.929	13				

a R Squared = .041 (Adjusted R Squared = -.133)

Exercise-Induced Feelings

Between GROUP ANCOVA: post-test positive feeling score with baseline positive feeling score as the covariate.

Tests of Between-Subjects Effects

Dependent Variable: positive mood post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	695.245	2	347.623	10.005	.003	.645
Intercept	1.719	1	1.719	.049	.828	.004
POSITVE1	596.192	1	596.192	17.160	.002	.609
GROUP	3.061	1	3.061	.088	.772	.008
Error	382.183	11	34.744			
Total	14906.000	14				
Corrected Total	1077.429	13				

a R Squared = .645 (Adjusted R Squared = .581)

Between GROUP ANCOVA: post-test negative feeling score with baseline negative feeling score as the covariate

Tests of Between-Subjects Effects

Dependent Variable: negative mood post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	2.224	2	1.112	.080	.923	.014
Intercept	107.382	1	107.382	7.764	.018	.414
NEGATIV1	7.499E-02	1	7.499E-02	.005	.943	.000
GROUP	1.815	1	1.815	.131	.724	.012
Error	152.133	11	13.830			
Total	2443.000	14				
Corrected Total	154.357	13				

a R Squared = .014 (Adjusted R Squared = -.165)

Depression

Between GROUP ANCOVA: post-test depression with baseline depression as the covariate.

Tests of Between-Subjects Effects

Dependent Variable: ces-d post

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	372.801	2	186.401	3.192	.081	.367
Intercept	145.953	1	145.953	2.499	.142	.185
SUMCES1	125.087	1	125.087	2.142	.171	.163
GROUP	82.725	1	82.725	1.416	.259	.114
Error	642.413	11	58.401			
Total	2913.000	14				
Corrected Total	1015.214	13				

a R Squared = .367 (Adjusted R Squared = .252)

Correlation: Perceived Control and Depression

Correlations

		ces-d pre	ces-d post	perceived control pre	perceived control post
ces-d pre	Pearson Correlation	1.000	.535	-.507	-.510
	Sig. (2-tailed)	.	.049	.065	.063
	N	14	14	14	14
ces-d post	Pearson Correlation	.535	1.000	-.622	-.459
	Sig. (2-tailed)	.049	.	.017	.098
	N	14	14	14	14
perceived control pre	Pearson Correlation	-.507	-.622	1.000	.817
	Sig. (2-tailed)	.065	.017	.	.000
	N	14	14	14	14
perceived control post	Pearson Correlation	-.510	-.459	.817	1.000
	Sig. (2-tailed)	.063	.098	.000	.
	N	14	14	14	14

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Correlation: Pain and Depression

Correlations

		ces-d pre	ces-d post	PAIN pre	PAIN post
ces-d pre	Pearson Correlation	1.000	.535	.199	.432
	Sig. (2-tailed)	.	.049	.495	.123
	N	14	14	14	14
ces-d post	Pearson Correlation	.535	1.000	.055	.579
	Sig. (2-tailed)	.049	.	.853	.030
	N	14	14	14	14
PAIN pre	Pearson Correlation	.199	.055	1.000	.346
	Sig. (2-tailed)	.495	.853	.	.226
	N	14	14	14	14
PAIN post	Pearson Correlation	.432	.579	.346	1.000
	Sig. (2-tailed)	.123	.030	.226	.
	N	14	14	14	14

* Correlation is significant at the 0.05 level (2-tailed).

Correlation: Perceived Stress and Depression

Correlations

		ces-d pre	ces-d post	stress pre	stress post
ces-d pre	Pearson Correlation	1.000	.535	.589	.556
	Sig. (2-tailed)	.	.049	.027	.039
	N	14	14	14	14
ces-d post	Pearson Correlation	.535	1.000	.472	.605
	Sig. (2-tailed)	.049	.	.088	.022
	N	14	14	14	14
stress pre	Pearson Correlation	.589	.472	1.000	.844
	Sig. (2-tailed)	.027	.088	.	.000
	N	14	14	14	14
stress post	Pearson Correlation	.556	.605	.844	1.000
	Sig. (2-tailed)	.039	.022	.000	.
	N	14	14	14	14

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

1 RM – Left Shoulder Flexion

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	2.821	1	2.821	.393	.544
TIME * GROUP	Linear	1.090	1	1.090	.152	.704
Error(TIME)	Linear	79.045	11	7.186		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	7228.288	1	7228.288	44.893	.000
GROUP	.249	1	.249	.002	.969
Error	1771.116	11	161.011		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects
Dependent Variable: DLANTDEL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	750.483	1	750.483	1.461	.252
Intercept	541.033	1	541.033	1.054	.327
GROUP	750.483	1	750.483	1.461	.252
Error	5648.700	11	513.518		
Total	7046.519	13			
Corrected Total	6399.183	12			

a R Squared = .117 (Adjusted R Squared = .037)

1 RM – Right Shoulder Flexion

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	18.465	1	18.465	4.032	.070
TIME * GROUP	Linear	6.773	1	6.773	1.479	.249
Error(TIME)	Linear	50.381	11	4.580		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	7888.484	1	7888.484	58.705	.000
GROUP	.331	1	.331	.002	.961
Error	1478.131	11	134.376		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DRANTDEL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1859.976	1	1859.976	3.665	.082
Intercept	2298.608	1	2298.608	4.530	.057
GROUP	1859.976	1	1859.976	3.665	.082
Error	5581.804	11	507.437		
Total	10085.142	13			
Corrected Total	7441.781	12			

a R Squared = .250 (Adjusted R Squared = .182)

1 RM – Left Elbow Flexion

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	7.440	1	7.440	.623	.445
TIME * GROUP	Linear	36.012	1	36.012	3.017	.108
Error(TIME)	Linear	143.229	12	11.936		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	26964.583	1	26964.583	156.096	.000
GROUP	364.583	1	364.583	2.111	.172
Error	2072.917	12	172.743		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DLBICEPS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1153.434	1	1153.434	4.945	.046
Intercept	186.360	1	186.360	.799	.389
GROUP	1153.434	1	1153.434	4.945	.046
Error	2798.783	12	233.232		
Total	4031.263	14			
Corrected Total	3952.217	13			

a R Squared = .292 (Adjusted R Squared = .233)

1 RM – Right Elbow Flexion

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	1.288	1	1.288	.073	.792
TIME * GROUP	Linear	18.595	1	18.595	1.058	.326
Error(TIME)	Linear	193.304	11	17.573		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	28080.500	1	28080.500	116.554	.000
GROUP	195.885	1	195.885	.813	.387
Error	2650.149	11	240.923		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: delta right biceps (%)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	891.212	1	891.212	3.061	.108
Intercept	31.541	1	31.541	.108	.748
GROUP	891.212	1	891.212	3.061	.108
Error	3202.715	11	291.156		
Total	4156.908	13			
Corrected Total	4093.927	12			

a R Squared = .218 (Adjusted R Squared = .147)

1 RM – Left Chest Press

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	14.583	1	14.583	.218	.649
TIME * GROUP	Linear	157.440	1	157.440	2.349	.151
Error(TIME)	Linear	804.167	12	67.014		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	293171.503	1	293171.503	47.288	.000
GROUP	164.360	1	164.360	.027	.873
Error	74396.354	12	6199.696		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects
Dependent Variable: DLCHEST

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	407.726	1	407.726	2.020	.181
Intercept	.274	1	.274	.001	.971
GROUP	407.726	1	407.726	2.020	.181
Error	2421.543	12	201.795		
Total	2834.961	14			
Corrected Total	2829.269	13			

a R Squared = .144 (Adjusted R Squared = .073)

1 RM – Right Chest Press

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts
Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	7.354	1	7.354	.594	.456
TIME * GROUP	Linear	1.710	1	1.710	.138	.717
Error(TIME)	Linear	148.618	12	12.385		

Tests of Between-Subjects Effects
Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	25431.318	1	25431.318	43.392	.000
GROUP	1.417E-03	1	1.417E-03	.000	.999
Error	7033.006	12	586.084		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects
Dependent Variable: delta right chest (%)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	106.215	1	106.215	.306	.590
Intercept	172.637	1	172.637	.498	.494
GROUP	106.215	1	106.215	.306	.590
Error	4160.003	12	346.667		
Total	4484.160	14			
Corrected Total	4266.218	13			

a R Squared = .025 (Adjusted R Squared = -.056)

Summed Unilateral 1 RMs – Shoulder Flexion

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	35.720	1	35.720	1.740	.214
TIME * GROUP	Linear	13.297	1	13.297	.648	.438
Error(TIME)	Linear	225.818	11	20.529		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	30219.121	1	30219.121	52.472	.000
GROUP	5.723E-03	1	5.723E-03	.000	.998
Error	6335.033	11	575.912		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DSUMDELT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1181.527	1	1181.527	3.683	.081
Intercept	1085.030	1	1085.030	3.383	.093
GROUP	1181.527	1	1181.527	3.683	.081
Error	3528.423	11	320.766		
Total	5983.701	13			
Corrected Total	4709.950	12			

a R Squared = .251 (Adjusted R Squared = .183)

Summed Unilateral 1 RMs – Elbow Flexion

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	3.028	1	3.028	.055	.819
TIME * GROUP	Linear	98.220	1	98.220	1.784	.209
Error(TIME)	Linear	605.506	11	55.046		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	104844.322	1	104844.322	130.751	.000
GROUP	861.630	1	861.630	1.075	.322
Error	8820.461	11	801.860		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DSUMBCPS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	968.823	1	968.823	4.083	.068
Intercept	18.495	1	18.495	.078	.785
GROUP	968.823	1	968.823	4.083	.068
Error	2609.919	11	237.265		
Total	3582.397	13			
Corrected Total	3578.741	12			

a R Squared = .271 (Adjusted R Squared = .204)

Summed Unilateral 1 RMs – Chest Press

2-GROUP, 2-TIME Mixed 2-Way ANOVA examining absolute data

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Linear	15.562	1	15.562	.555	.471
TIME * GROUP	Linear	5.614	1	5.614	.200	.663
Error(TIME)	Linear	336.515	12	28.043		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	97201.605	1	97201.605	42.757	.000
GROUP	14.588	1	14.588	.006	.937
Error	27279.896	12	2273.325		

1-Way between group ANOVA examining percentage difference scores

Tests of Between-Subjects Effects

Dependent Variable: DSUMCHST

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	213.854	1	213.854	.965	.345
Intercept	31.334	1	31.334	.141	.713
GROUP	213.854	1	213.854	.965	.345
Error	2659.129	12	221.594		
Total	2933.301	14			
Corrected Total	2872.983	13			

a R Squared = .074 (Adjusted R Squared = -.003)

APPENDIX D: PSYCHOLOGICAL MEASURE RELIABILITY

Reliability Coefficient – Post Test Beliefs Scale (Perceived Control)

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	BEL52	3.7857	.8018	14.0
2.	BEL62	4.2143	.8926	14.0
3.	BEL72	4.1429	.8644	14.0
4.	BEL82	4.4286	.6462	14.0

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	16.5714	5.8022	2.4088	4

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
BEL52	12.7857	4.3352	.2468	.8213
BEL62	12.3571	2.7088	.7817	.4990
BEL72	12.4286	3.0330	.6716	.5815
BEL82	12.1429	4.1319	.4769	.7061

Reliability Coefficients

N of Cases = 14.0 N of Items = 4

Alpha = .7348

Reliability Coefficient – Baseline Beliefs Scale (Perceived Control)

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	BEL51	3.9286	.9169	14.0
2.	BEL61	4.0000	.7845	14.0
3.	BEL71	3.7143	.6112	14.0
4.	BEL81	4.4286	.5136	14.0

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	16.0714	5.7637	2.4008	4

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
BEL51	12.1429	2.5934	.7889	.7754
BEL61	12.0714	2.8407	.8727	.7195
BEL71	12.3571	3.9396	.5978	.8452
BEL81	11.6429	4.2473	.5918	.8538

Reliability Coefficients

N of Cases = 14.0 N of Items = 4

Alpha = .8491

Reliability Coefficient – Post Test Exercise Induced Feeling Inventory (Negative)

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	HRQL46C2	4.2143	1.3688	14.0
2.	HRQL46H2	4.2143	1.1217	14.0
3.	HRQL46K2	4.3571	1.1507	14.0

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	12.7857	11.8736	3.4458	3

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
HRQL46C2	8.5714	4.7253	.8864	.9070
HRQL46H2	8.5714	5.8022	.8907	.8977
HRQL46K2	8.4286	5.8022	.8563	.9205

Reliability Coefficients

N of Cases = 14.0 N of Items = 3

Alpha = .9371

Reliability Coefficient – Baseline Exercise Induced Feeling Inventory (Negative)

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	HRQL46C1	4.0000	1.1767	14.0
2.	HRQL46H1	4.1429	1.0995	14.0
3.	HRQL46K1	4.5714	1.1579	14.0

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	12.7143	9.6044	3.0991	3

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
HRQL46C1	8.7143	4.5275	.7374	.8738
HRQL46H1	8.5714	4.2637	.9100	.7216
HRQL46K1	8.1429	4.7473	.6969	.9074

Reliability Coefficients

N of Cases = 14.0 N of Items = 3

Alpha = .8856

Reliability Coefficient – Post Test Exercise Induced Feeling Inventory (Positive)

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	HRQL46A2	4.0000	1.3009	14.0
2.	HRQL46B2	3.1429	1.2924	14.0
3.	HRQL46D2	3.6429	1.2157	14.0
4.	HRQL46E2	3.5714	1.2839	14.0
5.	HRQL46F2	3.5714	1.1579	14.0
6.	HRQL46G2	2.8571	1.0271	14.0
7.	HRQL46I2	4.0000	1.3009	14.0
8.	HRQL46J2	3.5000	1.2247	14.0
9.	HRQL46L2	3.1429	1.2924	14.0

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	31.4286	82.8791	9.1038	9

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
HRQL46A2	27.4286	67.9560	.6169	.9401
HRQL46B2	28.2857	64.9890	.7784	.9305
HRQL46D2	27.7857	66.0275	.7781	.9305
HRQL46E2	27.8571	63.6703	.8571	.9257
HRQL46F2	27.8571	68.1319	.7014	.9347
HRQL46G2	28.5714	68.8791	.7593	.9323
HRQL46I2	27.4286	63.0330	.8789	.9243
HRQL46J2	27.9286	65.9176	.7775	.9305
HRQL46L2	28.2857	65.2967	.7618	.9315

Reliability Coefficients

N of Cases = 14.0 N of Items = 9

Alpha = .9384

Reliability Coefficient – Baseline Exercise Induced Feeling Inventory (Positive)

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	HRQL46A1	3.9286	1.0716	14.0
2.	HRQL46B1	2.7857	1.1883	14.0
3.	HRQL46D1	3.5714	1.2225	14.0
4.	HRQL46E1	3.6429	1.1507	14.0
5.	HRQL46G1	2.9286	.9972	14.0
6.	HRQL46I1	4.3571	1.0818	14.0
7.	HRQL46J1	3.5000	1.1602	14.0
8.	HRQL46L1	2.7857	1.4239	14.0
9.	HRQL46F1	3.5000	1.5064	14.0

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	31.0000	61.8462	7.8642	9

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
HRQL46A1	27.0714	53.6099	.4517	.8862
HRQL46B1	28.2143	48.0275	.7533	.8627
HRQL46D1	27.4286	49.0330	.6611	.8703
HRQL46E1	27.3571	49.4780	.6822	.8689
HRQL46G1	28.0714	50.2253	.7518	.8654
HRQL46I1	26.6429	53.3242	.4653	.8853
HRQL46J1	27.5000	51.3462	.5505	.8793
HRQL46L1	28.2143	44.9505	.7787	.8591
HRQL46F1	27.5000	46.1154	.6580	.8723

Reliability Coefficients

N of Cases = 14.0 N of Items = 9

Alpha = .8851

Reliability Coefficient – Post Test Perceived Stress Scale

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	HRQL282	2.3571	1.1507	14.0
2.	HRQL292	2.1429	.7703	14.0
3.	HRQL302	2.1429	1.0271	14.0
4.	HRQL312	2.2143	1.0509	14.0
5.	HRQL322	3.5000	1.4005	14.0
6.	HRQL332	3.0000	1.3587	14.0
7.	HRQL342	3.5000	1.0919	14.0
8.	HRQL352	2.0714	.9169	14.0
9.	HRQL362	2.5000	1.2247	14.0
10.	HRQL372	2.8571	1.2315	14.0
11.	HRQL382	2.1429	.6630	14.0
12.	HRQL392	3.6429	1.3927	14.0
13.	HRQL402	3.2143	1.4239	14.0
14.	HRQL412	1.9286	.8287	14.0

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	37.2143	98.3352	9.9164	14

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
HRQL282	34.8571	90.9011	.2784	.8843
HRQL292	35.0714	89.1484	.5907	.8715
HRQL302	35.0714	85.4560	.6227	.8682
HRQL312	35.0000	85.3846	.6100	.8686
HRQL322	33.7143	88.6813	.2916	.8871
HRQL332	34.2143	82.1813	.5808	.8700
HRQL342	33.7143	85.1429	.5955	.8691
HRQL352	35.1429	85.0549	.7356	.8644
HRQL362	34.7143	79.7582	.7806	.8588
HRQL372	34.3571	79.1703	.8053	.8574
HRQL382	35.0714	89.1484	.6987	.8696
HRQL392	33.5714	91.3407	.1899	.8925
HRQL402	34.0000	79.2308	.6737	.8646
HRQL412	35.2857	87.4505	.6579	.8685

Reliability Coefficients

N of Cases = 14.0 N of Items = 14

Alpha = .8795

Reliability Coefficient – Baseline Perceived Stress Scale

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	HRQL281	2.5000	.9405	14.0
2.	HRQL291	2.8571	1.4064	14.0
3.	HRQL301	2.9286	1.3281	14.0
4.	HRQL311	2.2857	.7263	14.0
5.	HRQL321	3.3571	1.0818	14.0
6.	HRQL331	2.2857	1.0690	14.0
7.	HRQL341	3.2857	.9945	14.0
8.	HRQL351	2.3571	1.0818	14.0
9.	HRQL361	2.8571	1.2924	14.0
10.	HRQL371	2.9286	1.1411	14.0
11.	HRQL381	2.5000	.7596	14.0
12.	HRQL391	3.6429	1.4469	14.0
13.	HRQL401	2.5000	1.0190	14.0
14.	HRQL411	2.1429	1.0271	14.0

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	38.4286	107.3407	10.3605	14

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
HRQL281	35.9286	95.3022	.6074	.8960
HRQL291	35.5714	89.1868	.6089	.8965
HRQL301	35.5000	85.8077	.8035	.8864
HRQL311	36.1429	94.4396	.8766	.8902
HRQL321	35.0714	103.3022	.1304	.9135
HRQL331	36.1429	91.9780	.6935	.8923
HRQL341	35.1429	90.7473	.8236	.8879
HRQL351	36.0714	89.6099	.8086	.8876
HRQL361	35.5714	88.8791	.6891	.8921
HRQL371	35.5000	90.1154	.7350	.8903
HRQL381	35.9286	102.2253	.2955	.9054
HRQL391	34.7857	96.1813	.3195	.9113
HRQL401	35.9286	94.8407	.5775	.8969
HRQL411	36.2857	92.8352	.6796	.8930

Reliability Coefficients

N of Cases = 14.0 N of Items = 14

Alpha = .9027

Reliability Coefficient – Post Test CES-D

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
DEP12	10.8571	65.8242	.7155	.8772
DEP22	10.8571	62.7473	.7928	.8737
DEP32	11.1429	65.2088	.8803	.8720
DEP42	11.1429	75.2088	.1752	.8942
DEP52	10.7143	68.6813	.5093	.8853
DEP62	11.2857	65.7582	.8515	.8732
DEP72	10.6429	65.1703	.7070	.8775
DEP82	11.2143	79.4121	-.1508	.9007
DEP92	11.5714	77.0330	.2108	.8911
DEP102	11.2143	70.6429	.6474	.8814
DEP112	10.3571	66.4011	.7290	.8769
DEP122	10.7143	69.2967	.8211	.8775
DEP132	10.9286	66.2253	.6721	.8789
DEP142	11.1429	69.2088	.7819	.8779
DEP152	11.5000	77.5000	.0722	.8929
DEP162	10.8571	79.3626	-.1338	.9036
DEP172	11.5714	78.7253	-.1483	.8947
DEP182	11.1429	70.2857	.6771	.8806
DEP192	11.5714	77.6484	.0793	.8924
DEP202	10.7857	67.4121	.6274	.8806

Reliability Coefficients

N of Cases = 14.0 N of Items = 20

Alpha = .8899

Reliability Coefficient – Baseline CES-D

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
DEP21	10.7143	52.2198	.1600	.8641
DEP31	10.5714	44.8791	.7473	.8400
DEP41	10.6429	48.7088	.3457	.8604
DEP51	10.3571	48.4011	.4561	.8539
DEP61	10.5000	46.5769	.6884	.8440
DEP11	10.4286	47.0330	.6597	.8454
DEP71	10.1429	53.5165	-.0120	.8757
DEP81	10.4286	46.1099	.6548	.8447
DEP91	10.7143	50.6813	.2248	.8647
DEP101	10.7143	47.6044	.5710	.8489
DEP111	9.9286	51.4560	.1767	.8659
DEP121	10.2857	45.6044	.7626	.8404
DEP131	10.4286	50.4176	.3849	.8563
DEP141	10.5714	48.8791	.5351	.8510
DEP151	11.0000	52.4615	.2925	.8592
DEP161	10.6429	46.0934	.8622	.8388
DEP171	11.0714	52.0714	.5157	.8565
DEP181	10.7143	47.1429	.7405	.8435
DEP191	11.0714	52.0714	.5157	.8565
DEP201	10.7857	52.3352	.2154	.8611

Reliability Coefficients

N of Cases = 14.0 N of Items = 20

Alpha = .8603

APPENDIX E:

DESCRIPTIVE STATISTICS FOR BODILY PAIN AND PERCEIVED CONTROL

Perceived Control – Descriptive Stats

		POST				PRE			
	Subject	1	2	3	4	1	2	3	4
Exercise	1	4	4	4	4	4	5	5	5
Group	2	5	5	5	5	5	5	5	5
	4	3	4	3	4	4	3	2	4
	5	4	4	3	5	2	5	5	5
	6	5	5	4	5	4	5	4	5
	12	5	5	4	5	5	5	5	5
	13	3	3	3	4	3	3	4	4
	14	4	4	4	5	4	5	5	5
Mean		**4.125**	**4.25**	**3.75**	**4.625**	**3.875**	**4.5**	**4.375**	**4.75**
SD		**0.835**	**0.707**	**0.707**	**0.518**	**0.991**	**0.926**	**1.061**	**0.463**
Control	3	4	4	4	4	4	4	4	4
Group	7	5	5	4	4	4	5	4	4
	8	4	4	4	5	4	4	4	3
	9	2	3	4	4	3	3	4	5
	10	3	3	3	4	3	3	3	4
	11	4	3	3	4	4	4	4	4
Mean		**3.667**	**3.667**	**3.667**	**4.167**	**3.667**	**3.833**	**3.833**	**4.000**
SD		**1.033**	**0.816**	**0.516**	**0.408**	**0.516**	**0.753**	**0.408**	**0.632**

Bodily Pain – Descriptive Stats

	Subject	Pain-pre	Pain-post
Exercise Group	1	5	5
	2	1	1
	4	1	2
	5	3	2
	6	2	2
	12	3	2
	13	4	3
	14	2	5
Mean		**2.625**	**2.75**
SD		**1.408**	**1.488**
Control Group	3	4	5
	7	2	2
	8	2	3
	9	1	6
	10	5	4
	11	4	4
Mean		**3**	**4**
SD		**1.549**	**1.414**

APPENDIX F:

GLOSSARY OF ABBREVIATIONS

GLOSSARY OF ABBREVIATIONS

1 RM – one repetition maximum

ACSM – American College of Sports Medicine

AD – autonomic dysreflexia

ADL – activities of daily living

ANCOVA – analysis of covariance

ANOVA – analysis of variance

ANS – autonomic nervous system

ARPE – arm rating of perceived exertion

BS – beliefs scale

BWST – body weight-supported treadmill training

C – control

CES-D – Centre for Epidemiological Studies depression questionnaire

CHD – coronary heart disease

DBP – diastolic blood pressure

EFI – C – exercise-induced feelings inventory

EX – exercise group

FBG – fasting blood glucose

FES – functional electrical stimulation

HDL – high-density lipoproteins

HR – heart rate

HRQL – health-related quality of life

KE – knee exercise

LDL – low-density lipoproteins

LS – life satisfaction

PPMC – Pearson product moment correlation

PSS – perceived stress scale

PWB – psychological well-being

QOL – quality of life

RPE – rating of perceived exertion

SBP – systolic blood pressure

SCI – spinal cord injury

SEM – standard error of the mean

SF- 36 – Short-Form 36-Item Health Questionnaire

SWB – subjective well-being

TC – total cholesterol

TG – triglycerides

TRPE – total body rating of perceived exertion

WR – work rate

APPENDIX G:

PSYCHOLOGICAL QUESTIONNAIRES

Name_____
Subject_____
Date_____
Inital/3 month/6 month/9 month

MEASURES OF DEPRESSION

Below is a list of some of the ways you may have felt or behaved. Please indicate how often you have felt this way during the **past week** by checking the appropriate space.

Rarely or none of the time (less than 1 day)	*Some or a little of the time (1-2 days)*	*Occasionally or a moderate amount of time (3-4 days)*	*All of the time (5-7 days)*
0	**1**	**2**	**3**

1. I was bothered by things that usually don't bother me. _____
2. I did not feel like eating; my appetite was poor. _____
3. I felt that I could not shake off the blues even with help from my family. _____
4. I felt that I was just as good as other people. _____
5. I had trouble keeping my mind on what I was doing. _____
6. I felt depresed. _____
7. I felt that everything I did was an effort. _____
8. I felt hopeful about the future. _____
9. I thought my life had been a failure. _____
10. I felt fearful. _____
11. My sleep was restless. _____
12. I was happy. _____
13. I talked less than usual. _____
14. I felt lonely. _____
15. People were unfriendly. _____
16. I enjoyed life. _____
17. I had crying spells. _____
18. I felt sad. _____
19. I felt that people disliked me. _____
20. I could not get "going". _____

Beliefs Scale

Name _____
Subject #_____
Date_____
Interviewer_____

1. How **important** do you think it is for you to **manage the symptoms** of a spinal cord injury?

Not at all important_____1
Somewhat important_____2
Moderately important_____3
Very important_____4
Extremely important_____5

2. How **important** do you think it is for you to **deal with the limitations** associated with a spinal cord injury?

Not at all important_____1
Somewhat important_____2
Moderately important_____3
Very important_____4
Extremely important_____5

3. How **important** do you think it is for you to **continue your activities** despite a spinal cord injury?

Not at all important_____1
Somewhat important_____2
Moderately important_____3
Very important_____4
Extremely important_____5

4. How **important** do you think it is for you to **follow your treatment regimen**?

Not at all important_____1
Somewhat important_____2
Moderately important_____3
Very important_____4
Extremely important_____5

5. How **much control** do you think you personally have over your ability to **manage the symptoms** of a spinal cord injury?

No control at all_____1
A little control_____2
Moderate control_____3
A lot of control_____4
Complete control_____5

6. How **much control** do you think you personally have over your ability **to deal with the limitations** associated with a spinal cord injury?

No control at all_____1
A little control_____2
Moderate control_____3
A lot of control_____4
Complete control_____5

7. How **much control** do you think you personally have over your ability **to continue your activities** despite your spinal cord injury?

No control at all_____1
A little control_____2
Moderate control_____3
A lot of control_____4
Complete control_____5

8. How **much control** do you think you personally have over your ability to **follow your treatment regimen**?

No control at all_____1
A little control_____2
Moderate control_____3
A lot of control_____4
Complete control_____5

9. How **confident are you** that you can **manage the symptoms** of spinal cord injury?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
no confidence at all somewhat confident completely confident

10. How **confident are you** that you can **deal with the limitations** associated with a spinal cord injury?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
no confidence at all somewhat confident completely confident

11. How **confident are you** that you can **continue your activities** despite your spinal cord injury?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
no confidence at all somewhat confident completely confident

12. How **confident are you** that you can **follow your treatment regimen**?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
no confidence at all somewhat confident completely confident

13. How **confident are you** that you can **attend exercise class** two times per week for the next 12 weeks?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
no confidence at all				somewhat confident					completely confident	

Name:_____
Subject:_____
Date:_____
Interviewer:_____

HRQL Form

We are interested in your opinions about your health and activities. Below are several questions about experiences that people may have day to day. Please read each question carefully and mark one box that best describes you. There are no right or wrong answers.

The following questions ask about your health and daily activities.

1. During the past 4 weeks on how many days did health problems cause you to do the following (for each question, please write in the number of days in the blank. Use a "0" if your answer is no days):

a.	Stay in bed all day or most of the day?	_____ Days in past 4 weeks
b.	Cut down on your usual activities all or most of the day	_____ Days in past 4 weeks
c.	Feel less well than usual for all or most of the day	_____Days in past 4 weeks

2. In general, would you say your health is:

☐	☐	☐	☐	☐
Excellent	Very Good	Good	Fair	Poor

3. Compared to one year ago, how would you rate your health in general now?

☐	☐	☐	☐	☐
Much better now	Somewhat better now	About the same	Somewhat worse	Much worse

The following questions are about your quality of life.

4. Here is a picture of a ladder. At the bottom of the ladder is the worst situation you might reasonably expect to have. At the top is the best you might expect to have. The other rungs are in between. Where on the ladder is your overall life satisfaction during the past 4 weeks? (Check one ☐)

- ☐ 9 Best life I could expect to have
- ☐ 8
- ☐ 7
- ☐ 6
- ☐ 5
- ☐ 4
- ☐ 3
- ☐ 2
- ☐ 1 Worst life I could expect to have

	In the past 4 weeks,how satisfied have you been with...	**Very Dissatisfied**	**Some-what Dis-satisfied**	**A little Dis-satisfied**	**Neither**	**A Little Satisfied**	**Some-what Satisfied**	**Very Satis**
.	how well you think and remember ?							
.	the amount of walking or wheeling you do ?							
.	how often you get outside the house, going into town, using public transportation or driving?							
.	how often you see or talk to your family and friends?							
.	the help you get from your family and friends ?							
0.	your contribution to your community, neighbourhood, religious or other group.							
1.	your retirement, or school, or current job ?							
2.	the kind and amount of recreation or leisure you have ?							
3.	your level of sexual activity or lack of sexual activity ?							
4.	how respected you are by others ?							
5.	the meaning and purpose of your life ?							
6.	the amount and kind of sleep you get ?							
7.	how happy you are ?							
8.	your overall level of physical activity ?							
9.	the muscle strength in your legs ?							
0.	your level of endurance or stamina ?							
.	your muscle tone ?							
.	your overall level of energy ?							

	In the past 4 weeks, how satisfied have you been with..	Very Dissatisfied	Somewhat Dissatisfied	A little Dissatisfied	Neither	A Little Satisfied	Some-What Satisfied	Very Satisf
3.	Your physical ability to do what you want or need to do ?							
4.	Your weight ?							
5.	Your shape ?							
6.	Your overall physical appearance ?							
7.	The muscle strength in Your arms ?							

Below are some statements that people may use to describe themselves. For each item, please check the one answer that describes how you <u>generally</u> feel.

	In the <u>past 4 weeks</u>, how much of the time have you..	All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
28.	been upset because of something that happened unexpectedly ?						
29.	felt that you were unable to control the important things in your life ?						
30.	felt nervous and "stressed" ?						
31.	dealt unsuccessfully with irritating life hassles ?						
32.	felt that you were effectively coping with important changes that were occurring in your life ?						
33.	felt confident about your ability to handle your personal problems ?						
34.	felt that things were going your way ?						
35.	found that you could not cope with all the things that you had to do ?						
36.	been able to control irritations in your life ?						
37.	felt that you were on top of things ?						

	In the past 4 weeks, how much of the time have you...	All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
38.	been angered because of things that happened that were outside of your control ?						
39.	found yourself thinking about things that you have to accomplish ?						
40.	been able to control the way you spend your time?						
41.	felt difficulties were piling up so high that you could not overcome them?						

The next four questions ask about any bodily pain you may have experienced.

		None	Very mild	Mild	Moderate (medium)	Severe	Very severe
42.	During the past 4 weeks, how much bodily pain have you had ?						
43.	In the past week, how much shoulder pain have you experienced while wheeling ?						
44.	In the past week, how much shoulder pain have you experienced in general ?						

45. During the past 4 weeks, how much did pain interfere with your normal work (both outside your home and at home?)

☐ Not at all ☐ A little bit ☐ Moderately (Medium) ☐ Severe ☐ Very Severe

The following questions ask about your thoughts and feelings.

46. Over the past WEEK to what extent have you felt each of the following moods (Check one answer for each item a through l).

		All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
a.	Refreshed						
b.	Calm						
c.	Fatigued						
d.	Enthusiastic						
e.	Relaxed						
f.	Energetic						
g.	Happy						
h.	Tired						
i.	Revived						
j.	Peaceful						
k.	Worn-out						
l.	Upbeat						