PSYCHOLOGICAL BENEFITS OF EXERCISE FOR INDIVIDUALS WITH SCI

EXERCISE AS A STRATEGY FOR THE REDUCTION OF PAIN AND ENHANCEMENT OF PSYCHOLOGICAL AND SUBJECTIVE WELL-BEING IN INDIVIDUALS WITH SPINAL CORD INJURY: THE RESULTS OF A 9-MONTH RANDOMIZED CONTROLLED TRIAL.

By

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A thesis

Submitted to the School of Graduate Studies

In Partial Fulfillment of the Requirements

For the Degree

Master of Science

McMaster University

MASTER OF SCIENCE (2001) McMaster University
(Human Biodynamics) Hamilton, Ontario

TITLE: Exercise as a Strategy for the Reduction of Pain and Enhancement of Psychological and Subjective Well-Being in Individuals with Spinal Cord Injury: The Results of a 9-Month Randomized Controlled Trial.

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NUMBER OF PAGES: ix, 130

Abstract

Chronic pain is a frequent and debilitating comorbidity of SCI (Ravenscroft et al., 2000). Although exercise is an effective strategy for managing pain in other chronic pain populations (e.g., Ettinger et al., 1997), exercise training has not been previously examined in the SCI population. In a RCT of 34 sedentary men and women with traumatic SCI, the effects of exercise on perceived pain and physical and psychological well-being were examined. Additionally, the efficacy of exercise as a pain management strategy was assessed. Exercisers performed aerobic and resistance training twice weekly over 9-months. Controls maintained their usual level of activity. Measures of pain (Ware & Sherbourne, 1992), physical well-being (Reboussin et al., 2000), stress (Cohen et al., 1992), depression (Radlof, 1977) and subjective well-being (Cantril 1965; Patrick et al., 1988) were administered at baseline and at the 3, 6 and 9 months points of the intervention. A series of ANCOVAs adjusted for baseline scores revealed a significant group main effect for the measures of pain, stress, depression and subjective well-being which reflected improvement in all of these domains for the exercisers (i.e., decreased pain, stress and depression and increased subjective well-being) and decrement in all of these domains for the controls ($ps < .05$). Hierarchical linear regression analyses (cf. Baron & Kenny, 1986) revealed that change in physical well-being partially mediated change in pain, change in pain mediated change in stress and subjective well-being and change in stress mediated change in depression. These findings suggest that variables mediating exercise-induced change should be targeted to maximize the effectiveness of exercise as a pain management strategy for individuals with SCI. The therapeutic and theoretical implications of these findings are discussed.

Acknowledgements

Who knew that Dr. Diane Ste-Marie's invitation to work in her research lab at the University of Ottawa would eventually lead me to an M.Sc. degree?

Who knew that the young scholar whose conference presentation sparked my interest in Exercise Psychology would one day be my graduate advisor?

Who knew that monstrous long distance phone bills was all it would take for me to appreciate my family and friends in Ottawa more than ever before and for me to make new and lasting friendship in Hamilton?

All I know is...***Everything happens for a reason!***

Over the past year there have been many important people who have given me reason to continue on this challenging journey through academia that I would like to thank. Firstly, I must thank my family and friends for their unwavering support. It was amazing how either a hug from my Mom or a word of encouragement from my Dad made writing one last paragraph a surmountable task. The numerous inquiries – "just wondering how you are doing?" – from friends always provided motivation to keep going.

Dr. Kathleen Martin and my labmates are a second group of people whose support was greatly appreciated. Kathleen, my graduate advisor, played and continues to play a vital role in my academic pursuits. Her gentle guidance led me to achieve a level of thought and written communication that I never knew I was capable of reaching. She is an incredible role model for many.

From my experience, along with a great advisor comes a great lab group. Having had the opportunity to learn along side many outstanding student researchers at both the University of Ottawa and at McMaster University has made being involved in research a most enjoyable experience. I have learned that the perspective of a peer is an invaluable tool in research – to all of my labmates thank you for sharing your perspective on many research questions.

Just like an Academy Award winning actress, I still have so many people left to thank. I would like to thank my thesis committee members (Dr. Larry Brawley from the University of Waterloo, Dr. Nicole Culos-Reed from the University of Calgary and Dr. Neil McCartney from McMaster University) for their thorough reviews of my thesis and for challenging me to broaden my view of intervention based research. Thank you Dr. Hicks for allowing me to be part of your research team. A very special thanks to all of the study participants – a truly inspiring group of people. The many student volunteers who helped to train and test the exercise participants must also be acknowledged. As a result of the student volunteers' dedication, the MacWheeler Exercise Program was a great success.

Lastly, I would like to acknowledge the Natural Science and Engineering Research Council of Canada for funding my academic pursuits.

Thank you all you great people

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1.1 Spinal Cord Injury: Epidemiological Considerations

1.1.1 Incidence and prevalence of spinal cord injury

In addition to the 36,000 Canadians already living with a spinal cord injury (SCI), 1,050 individuals become injured each year and 82% of those injured are male (Canadian Paraplegic Association, 2001). Often occurring in an instant, the physiological damage and the functional loss associated with a traumatic SCI have a devastating impact that lasts a lifetime (Coyle, Lesnick-Emas & Kinney, 1994). With 19 years being the most common age at time of injury (National Spinal Cord Injury Association, 2001) and with advances in medical technology aiding to lengthen the life span of individuals with SCI (Cohen, McArthur, Vulpe, Schandler, & Gerber, 1988; Evans, Hendricks, Connis, Haselkorn, Ries & Mennet, 1994; McColl, Stirling, Walker, Corey & Wilkins, 1999; North, 1999; Whiteneck et al., 1992a), injured individuals may be faced with a long period of survival with impaired functioning.

1.1.2 Determinants of functional loss

Although the amount of functional loss associated with an SCI is unique to each injury, the nature of the impairment is determined by the completeness and the level of the lesion on the spinal cord (American Spinal Injury Association, 1992). With regards to the completeness of an injury, a lesion that completely severs the spinal cord leaving no motor or sensory function inferior to the site of damage is defined as a complete injury. Injuries in which sensory and/or motor function are partially preserved below the neurological level, including the lowest sacral segment of the spinal cord, are defined as incomplete. The prevalence of incomplete injuries is slightly greater than that of complete injuries (i.e., 55% of SCI are incomplete, 45% of SCI are complete; National Spinal Cord Injury Association, 2001). Depending on the level of the lesion, the injury results in either tetraplegia or paraplegia. Tetraplegia is the condition in which damage is localized to the cervical segments of the spinal cord and results in the impairment of function in the arms, trunk, legs and pelvic organs. Forty-eight percent of SCI result in tetraplegia (National Spinal Cord Injury Association, 2001). Conversely, paraplegia is the impairment or loss of motor and/or sensory function in the thoracic, lumbar or sacral segments of the spinal cord. For individuals with paraplegia, arm functioning is spared, but depending on the level of injury, the trunk, legs, and pelvic organs may be impaired. The prevalence of paraplegia, only slightly greater than that of tetraplegia, is 51% (National Spinal Cord Injury Association, 2001). Thus, injuries can be either complete or incomplete, resulting in either tetraplegia or paraplegia. For additional definitions of SCI related terms (e.g., impairment, disability and handicap) refer to Appendix A.

1.1.3 Secondary impairments associated with spinal cord injury

Individuals with SCI frequently report secondary impairments. However, due to the catastrophic, life-threatening nature of the injury, little appreciation is given to the extent and nature of these secondary conditions. Because the disabling aspects of SCI often consume the attention of clinician-scientists, the comorbidities associated with SCI are poorly understood and controlled research examining these conditions is lacking. Examples of secondary impairments include osteoporosis, urinary track infections, pressure sores and chronic pain (Gerhart, Johnson & Whiteneck, 1992; Noreau, Proulx, Gagnon, Drolet & Laramee, 2000; Uebelhart, Demiaux-Domenech, Roth & Chartrain, 1995). For many of these conditions that are related to body function impairment, medical interventions exist for their prevention or alleviation. For example, a regime of "bone building drugs" such as fosamax is instrumental in preventing osteoporosis (Fleisch, 1987), a course of antibiotics and catheterization help to resolve a urinary tract infection (Dmochowski, Ganbathi & Leache, 1995; Galloway, 1997), and bed rest and in more severe cases, surgical intervention aid the healing of pressure sores (Garber, Rintala, Rossi, Hart & Fuhrer, 1996; Longe, 1986; Schryvers, Stranc & Nance, 2000). In addition, chronic pain is frequently managed through the use of medication, cognitive-behavioral counseling and physical rehabilitation (Balazy, 1992; Ragnarsson, 1997; Richards, 1992; Umlauf, 1992). Although many pain management interventions are available, a single most effective intervention to reduce chronic pain is yet to be determined (Bowsher, 1999).

1.2 Chronic Pain: A Comorbidity of SCI

With limited clinical appreciation for chronic pain in the SCI population, the pain phenomenon is complex and poorly understood (Ravenscroft, Ahmed & Burnside, 1999). However, many individuals with SCI report that chronic pain is the most debilitating problem they face (Paralyzed Veterans of America, 1988; Ravenscroft, Ahmed & Burnside, 2000; Widerstrom-Noga, Felipe-Cuervo, Bronton, Duncan, Yezierski, 1999). Physical functioning status, psychological well-being and social relationships are often hindered by chronic pain symptoms (Dalyan, Cardenas & Gerard, 1999; Davidoff, Roth, Guarracini, Sliwa, Yarkony, 1987; Rintala, Loubser, Castro, Hart & Fuhrur, 1998; Wegener & Elliot, 1992). Consequently, individuals with SCI who suffer from chronic pain have a lower quality of life as compared to individuals with SCI who are pain free (Anke, Stenhjem & Stanghell 1995). Thus, there is a need for an effective intervention to reduce chronic pain, and in turn, restore quality of life.

1.2.1 Prevalence and severity of chronic pain in individuals with SCI

In reviewing the chronic pain and SCI literature, the prevalence, severity, various types of pain and the life altering impact of these chronic pain symptoms become apparent. Generally, at the onset of an SCI, acute pain is reported by most SCI patients (Cairns, Adkins & Scott, 1996; New, Lim, Hill & Brown, 1997; Sved, Siddall, McClelland & Cousins, 1997). Chronic pain, the persistence of pain symptoms for a minimum of 3 months (Altmaier, Russell & Koa, 1993), has been estimated to affect 18-94% of people with SCI post-hospitalization (Bowsher, 1999; Lamid, Chia, Kohli & Chid, 1985; Ravenscroft et al., 1999; Rintala et al., 1998; Siddall, Taylor, McClelland, Rutkowski, Cousins, 1999; Siddall, Taylor & Cousins, 1997) and throughout life (Mariano, 1992.). The considerable variability in the number of people estimated to experience chronic pain (18-94%) is reflective of the inconsistent criteria used to classify individuals as chronic pain sufferers (Ravenscroft et al., 1999; Siddall et al., 1997, Siddall et al., 1999). In addition to the high prevalence of pain among people with SCI, of further concern is the observation that 30-40% of chronic pain sufferers report that the pain is severe and/or disabling (Loubser & Donovan, 1996; Nepomuceno, Fine, Richards, Gowens, Stover, Rantanuabol & Houston, 1979; Ravenscroft et al., 2000; Stromer et al., 1997; Summers, Rapoff, Varghese, Porter, & Palmer, 1991; Sved et al.,1997). Thus, for an individual who has sustained an SCI, chronic pain can further affect physical functioning and handicap beyond levels attributable to the SCI injury per se (Lamid et al., 1985; Rintala et al., 1998).

The majority of research on chronic pain in individuals with SCI has been descriptive and has attempted to identify potential correlates of pain intensity. Across the pain research, there is general consensus that violent etiology, greater age, greater years post injury, emotional distress (e.g., anxiety, depression) and a negative familial-social environment are associated with greater self-reported pain (Richards, Meredith, Nepomuceno, Fine & Bennett, 1980; Rintala et al., 1998; Stromer et al., 1997; Summers et al., 1991). Yet while there is consensus regarding the effects of psychosocial factors on pain, there is inconclusive evidence regarding the moderating effects of the level of impairment on pain symptoms (Davidoff et al., 1987). Some studies indicate that individuals with a lower level of impairment (e.g., paraplegia) experience more severe pain than individuals with a higher level of impairment (e.g., tetraplegia; Davis & Martin, 1947; Nepomuceno et al., 1979; Rintala et al., 1998). In contrast, a large body of evidence exists indicating that level of impairment and the completeness of the injury have no effect on the severity of pain symptoms (Anke et al., 1995; Cohen et al., 1988; Mariano, 1992; Richards et al., 1980; Siddall et al, 1999; Summers et al., 1991). Regardless of these inconsistencies in the existent body of literature, one fact has been clearly established - pain is a significant complaint in the SCI population.

Interestingly, of the many potential pain correlates identified, psychosocial variables are the most easily modified (e.g., emotional distress can be reduced through cognitive behavioral interventions [Umlauf, 1992] whereas many of the other variables such as the demographic variable years post injury cannot be affected by any type of intervention). Thus, when designing an effective strategy for the reduction of chronic pain, components of the intervention should be aimed at improving an individual's psychosocial situation. For example, pain reduction interventions might include anxiety reduction techniques and education sessions for family members. If successful, interventions with the two-pronged approach of reducing pain and improving psychological well-being have great promise for enhancing a chronic pain sufferer's overall sense of well-being.

1.2.2 The types of pain experienced by individuals with SCI

When attempting to understand the complexities of chronic pain in the SCI population, knowledge regarding the several types of pain reported by this population is essential. From an extensive review of the SCI literature, Siddall and colleagues (1997) have developed a comprehensive pain classification model for individuals with SCI. Within this model, 4 classes of pain were identified: musculoskeletal, visceral, neuropathic and "other types of pain." Musculoskeletal pain includes pain arising from damage or overuse of skeletal structures resulting in dull and aching pain symptoms. Visceral pain is characterized by symptoms such as dull, cramping pain isolated to the abdomen and related to visceral functioning. Neuropathic pain is the pain that occurs following damage to the central or peripheral nervous system. According to Siddall and colleagues' classification system, this class of pain can be further divided on the basis of the site of pain to include two subclasses of neuropathic pain: neuropathic pain above the site of the lesion and neuropathic pain below the site of the lesion. The last category, "other types of pain," includes all other types of pain that are a consequence of a SCI, such as headache associated with dysreflexia.

Of these 4 pain classes, musculoskeletal and neuropathic pain are the types most commonly reported by individuals with SCI (Davidoff et al., 1987; New et al., 1997; Siddall et al., 1999). In a prospective study, 40% of the 58 people with traumatic SCI interviewed reported having musculoskeletal pain 6 months post injury(Siddall et al., 1999). Further, 36% of these 58 individuals reported neuropathic pain above the site of the injury and 19% reported neuropathic pain below the level of the lesion at the same post injury time period.

Interestingly, in reviewing Siddall and colleagues' (1997) pain classes, many authors would suggest that an important pain class, psychogenic pain, was overlooked (Donovan, Dimitijevic, Dahm & Dimitrijevic, 1982; Kaplan, Grynbaum, Lloyd & Rusk, 1962). Psychogenic pain includes pain symptoms independent of increased or decreased sensory input and is thought to have a psychological origin (Donovan et al., 1982; Greziak, Ury, Dworkin, 1996; Kaplan et al., 1962). The inclusion of an explicit psychogenic pain category into Siddall and colleagues' pain classification system would cause the system to conform to the traditional dichotomous biomedical view in which pain symptoms are either somatogenic or psychogenic (Turk, 1996). This biomedical view has been heavily criticized because it fails to account for the dynamic interaction of psychological variables with pathophysiological factors (Engel, 1977).

To avoid the shortcomings of the biomedical model, instead of being a category of its own, Siddall and colleagues suggested that the psychogenic pain category be integrated into all pain categories. Thus, according to this classification system, within each of the four pain categories, psychological and physiological factors interact to create pain perceptions. By adopting an integrative biopsychosocial approach, an explanation for why physical pathology does not always predict pain severity and why pain severity does not always adequately explain psychological distress can be advanced (Turk, 1996). This view is particularly appropriate for the SCI population, where the level of disability is not clearly related to pain severity (Davidoff et al., 1987). Moreover, in acknowledging that pain is more than physical symptoms, it is evident that to understand the impact of chronic pain on an individual's life it is necessary to examine how the physical and psychological well-being of the chronic pain sufferer is affected by pain's lingering presence.

1.3 The Relationship Between Chronic Pain and Physical Well-Being in Individuals with SCI

For many individuals with SCI, the functional impairment associated with the actual injury is compounded by pain (Rintala et al., 1998). When examining the association between physical impairment and pain, many researchers use subjective measures of physical function such as disability, handicap and ability to perform activities of daily living, as indirect or proxy indicators of physical change and well-being. Often these subjective measures are more sensitive to change in physical well-being in individuals with SCI and are better predictors of other related, subjective variables such as stress than objective test values such as VO_2 max (Manns & Chad, 1999; Plante, LeCaptain & McLain, 2000).

Through the use of these indirect, subjective measures of physical well-being, the physically disabling effects of pain have begun to be understood. It has been determined that pain severe enough to interfere with activities of daily living is a complaint for 5-65% of people with SCI who report chronic pain (Dalyan et al., 1999; Kaplan et al., 1962; Lamid et al.,1985; Nepomuceno et al., 1979; Ravenscroft et al., 2000; Rose, Robinson, Ellis & Cole, 1988). This pain-related interference was clearly exhibited in a survey of 885 outpatients with SCI in which 83% of the respondents who were employed said that pain interfered with their work (Rose et al., 1988). Moreover, 36% of the sample who were unemployed cited pain as the primary cause for unemployment.

In another study examining pain and physical functioning, the negative relationship between the two constructs was once again confirmed (Rintala et al., 1998). A linear regression analysis on data collected from 77 men with SCI living in the community indicated that pain was a significant predictor of scores on a measure of disability, the Functional Independence Measure (FIM [Hamilton, Granger, Sherwin, Zieleny & Tashman, 1987]). In particular, the presence of upper extremity pain was related to lower FIM scores indicating that pain was associated with lower physical functioning. Therefore, as indicated indirectly by measures of physical functioning, it is apparent that pain severely interferes with an individual's ability to perform daily activities.

It has been hypothesized that the relationship between pain and physical functioning may be reciprocal, such that just as an increase in pain has been found to lead to a decrease in physical functioning, an increase in physical functioning has been hypothesized to lead to a decrease in pain (Balazy, 1992; Ragerson, 1997; Umlauf, 1992). Strong empirical support for this hypothesis is lacking in the SCI literature and is only moderately supported in the general chronic pain literature (e.g. Ettinger et al. 1997: Buckelew et al., 1998; McCain, Bell, Mai & Halliday, 1988). An example of the modest support for the latter hypothesis in the general pain literature can be drawn from a study comparing the effects of cardiovascular training to the effects of a stretching program on the manifestation of fibromyalgia symptoms in 42 fibromyalgia participants (McCain et al, 1988). At the completion of the 20-week intervention trial it was determined that the participants in the cardiovascular training group had improved fitness scores compared to the stretching group. Additionally, changes in pain threshold scores were observed for participants in the cardiovascular training group only. These findings are in accordance with the suggestion that one way to decrease pain threshold is to increase physical function. However, because changes in pain threshold and changes in physical function were measured simultaneously, it cannot be concluded that the cardiovascular changes preceded the improvement in pain threshold. To confirm this hypothesis, an exercise intervention study with a time-lagged experimental design must be conducted.

1.4 The Relationship Between Chronic Pain and Psychological Well-Being in Individuals with SCI

Physiological well-being is a central component of chronic pain. However, as the research perspective shifts from the disease-based biomedical model to the illness-based biopsychosocial perspective, it has become clear that biology is not the single determining factor of pain symptoms. Rather, psychosocial factors also play an important role in chronic pain. A large body of evidence exists that suggests that chronic pain is associated with psychological impairment (Cairns et al., 1996; Haythornthwaite & Bernrud-Larson, 2000; Mariano, 1992; Richards et al., 1980; Rintala et al., 1998; Siddal et al, 1997; Summers et al, 1991; Umlauf, 1992; Wegner & Elliot, 1992). More specifically, stress (Rintala et al. 1998; Summers et al., 1991) and depressive symptoms (Cairns et al., 1996; North, 1999) have been identified as psychosocial factors associated with pain in individuals with SCI. An extensive review of the relationship between pain and these two components of psychological well-being is conducted in the follows.

1.4.1 Chronic pain and stress

Individuals with SCI encounter many physiological and psychological stressors throughout their lives. The injury itself is a serious assault on the body's biological systems resulting in a chain of stress responses. Other psychosocial stressors frequently encountered by this group include unemployment, financial uncertainty, divorce and altered social roles (Gerhart, Weitzenkamp, Kennedy, Glass, & Charlifue, 1999; Gerhart et al., 1992). In addition to these significant stressors, individuals who suffer from chronic pain often consider their pain as well as the physical limitations it produces to be a prominent stressor in their lives (Turner, Clancy, & Vitaliano, 1987).

The relationship between stress and pain has been well established empirically in the SCI population. In a community-based sample of 661 men with SCI, upper extremity pain and ratings of maximal pain severity were significant predictors of scores on the Perceived Stress Scale (Cohen, Kamarck & Mermelstein, 1983; Rintala et al. 1998). The results of a linear regression analysis provided evidence that both the presence of upper-body pain and higher ratings of maximal pain severity were related to an increased level of perceived stress. From these findings it can be hypothesized that an intervention that reduces pain should in turn, lead to a reduction in perceived stress. However, this suggestion is only hypothetical and requires further experimental testing in the SCI population in particular. An investigation of the effectiveness of an intervention targeting pain as a means for reducing stress for individuals with SCI has yet to be conducted.

In addition to studies that have actually assessed an individual's perceived level of stress (e.g., Rintala et al., 1998), many studies have examined the relationship between pain and stress using indirect indicators of stress (e.g., Summers et al., 1991). These alternative measures assess negative affect, the resultant emotional response to an event appraised as being stressful (Lazarus, 1991; Lazarus & Folkman, 1984). Because individuals with chronic pain often appraise their pain as being stressful, they often experience a wide variety of negative emotions such as anxiety, hostility and anger (Devine, 1999; Gallagher, Cronan, Walen, Cronan & Tomita, 2001; Robinson & Riley, 1999).

This association of negative affect with chronic pain has been described in samples of individuals with SCI (Cohen, et al., 1988; Summers et al., 1991; Rintala et al., 1998; Richards, 1980). For example, pain severity in a sample of 54 people with SCI and chronic pain was positively correlated scores on the on the anger-hostility subscale of the Profile of Mood States (McNair, Lorr & Droppleman, 1981) and negatively correlated with scores on the vigor subscale. Similarly, in a study of 356 individuals with SCI, it was determined that another negative emotion, "anxiety," was a significant predictor of pain severity (Richards et al., 1980). Taken together, these studies indicate that for individuals with SCI, higher levels of pain are associated with greater negative emotions such as anger/hostility and anxiety. However, from these correlational studies, conclusions about the causal relationship between pain and stress cannot be drawn. Until it is determined whether a decrease in pain leads to a decrease in stress and negative affect or whether a decrease in stress and negative affect leads to a decrease in pain, it might be beneficial for interventions to target both factors in order to maximize the likelihood of a decrease in chronic pain.

1.4.2 Chronic pain and depression

It is well documented that depression is more prevalent in the SCI population than in the general population (Craig, Hancock & Dickson, 1994; Fuhrur, Rintala, Hart, Clearman & Young, 1993; Coyle, Shank, Kinney & Hutchins, 1993). Higher rates of depression have also been estimated for individuals with chronic pain than for the general population (Banks & Kerns, 1996). Thus, it is not surprising that among the SCI population, greater pain is a factor associated with even greater depression (Boekamp, Overholser & Schubert, 1996; Elliott & Frank, 1996; Mariano, 1992; Nepomuceno et al, 1979; Rintala et al., 1998; Summers et al., 1991). In Rintala and colleagues' (1998) descriptive study of the pain experience among individuals with SCI, participants who acknowledged having chronic pain had more depressive symptoms than those who reported no pain. Additionally, depression was significantly related to scores on the Zung Pain and Distress scale (Zung, 1983). From this relationship, it was revealed that an increase in depressive symptoms was associated with an increase in pain and distress scores. Findings from this study provide a basis for the development of a description of the relationship between pain and depression in individuals with SCI.

In an effort to advance the understanding of the pain and depression relationship, a process analysis was conducted to examine how the relationship between pain and depression develops over time (Cairns et al., 1996). Pain intensity and depressive symptoms were assessed for 68 acute traumatic SCI patients at admission and at discharge from a rehabilitation program. At admission, pain and depression were independent of each other. At discharge, a significant positive correlational relationship between both factors was reported, thus supporting the view that the relationship between pain and depression develops over time.

Further, it was determined that the presence of pain affected depression more than the presence of depression affected pain (Cairns et al., 1996). Subjects with persistent pain throughout the study showed moderate levels of depression at discharge, whereas those participants whose pain was eliminated by discharge had a dramatic reduction in depressive symptoms at the conclusion of the study. Participants with delayed onset of pain such that they reported no pain at admission but did report pain at follow-up assessments, showed increased depression between admission and discharge. Thus, according to these findings, for individuals who are suffering from depression and who have chronic pain associated with SCI, a pain reduction strategy should be implemented to alleviate pain symptoms and should, in turn , lead to a decrease in depressive symptoms.

Although the findings from this prospective study provide some support for undertaking pain reduction strategies for the alleviation of depressive symptoms in pain sufferers, the results must be interpreted cautiously due to a weak study design. In this repeated measures study, pain and depression were measured concurrently at admission and discharge. To test the hypothesis that a reduction in pain precedes a reduction in depression, it would have been more appropriate to use a time-lagged design with frequent measurement periods. In such a design, the predictor variable (e.g. pain) and the outcome variable (e.g. depression) are measured at separate instances. Further, because in a time-lagged analysis it is not only important to determine that changes in a variable occurred but also when the changes occurred in relation to the other variables being measured, more frequent measurement periods are required. Together, using frequent and separate measurement periods for each variable, it is possible to determine whether changes in the predictor variable are antecedent to changes in the outcome variable. In the SCI literature, studies using this experimental design have yet to be conducted.

This "chicken or egg" chronic pain and depression dilemma is also unresolved in the general, chronic pain literature (Gamsa, 1990; Gatchel, 1996; Magni, Moreschi, Rigatti-Luchini & Merskey, 1994). One study that employed a time-lagged design found that in the general population, musculoskeletal pain predicted the development of depression at an 8-year follow-up assessment (Magni et al., 1994). Conversely, depressive symptoms predicted the development of chronic pain at the follow-up assessment period as well. Although the former effect was slightly larger than the latter effect, it remains undetermined whether depression promoted pain or whether pain promoted depression. Until more conclusive results emerge, it seems reasonable to extrapolate that an intervention that reduces pain should be associated with a concomitant reduction in depression.

1.5 The Relationship Between Chronic Pain and Subjective Well-Being

In order to gain a comprehensive understanding of the impact of disability and physiological and psychological impairment on the life of an individual with SCI, research has begun to consider the effects of disability and impairment on people's overall quality of life (Clayton & Chubon, 1994; Dijkers, 1999; Fuhrer, 1996; Siosteen, Lundqvist, Blomstrand, Sullivan & Sullivan, 1990). Quality of life is a broad construct that encompasses diverse life domains with both objective and subjective determinants. Financial status, air quality and accessibility to the surrounding environment are examples of only a few aspects of objective quality of life (Guyatt, Feeney & Patrick, 1991). Although the objective domains of quality of life for the general population and the spinal cord population are similar, the importance each population places on these domains differs (Coyle et al., 1994; Kannisto & Sintonen, 1997). Research suggests that individuals with a disability proceed through a cognitive restructuring process in which traditional societal values and beliefs are challenged and replaced with values more relevant to the individual's physical condition and perceptions of his or her condition (Weinberg, 1984; Wright, 1960). As a result of this cognitive restructuring, the critical element in understanding the lifestyle of individuals with a disability such as SCI becomes the individual's cognitions. Therefore, a person's subjective appraisal of his/her quality of life becomes equally - if not more important - than objective indicators of quality of life (Coyle et al.,1994). This important subjective component of quality of life reflects "the degree to which people have positive thoughts and feelings about their lives…as a whole" (p. 56, Fuhrer, 1996) and is often described as subjective well-being or life satisfaction (Krause, 1998; Post, Van Dijk, Van Asbeck & Schrijvers, 1998; Richards, Bombardier, Tate, Dijkers, Gordon, Shewchuck & DeVivo, 1999).

Just as subjective well-being is a key determinant of general quality of life, subjective well-being is also a central component of a more narrow type of quality of life frequently examined in clinical populations – health-related quality of life. According to the current view of health related quality of life (Guyatt et al., 1991; Rejeski, Brawley & Shumaker, 1996; Rejeski & Shumaker, 1994; Wood, Reyes-Alvarez, Maraj, Metoyer & Welsch, 1999), this concept consists of "those attributes valued by patients including resultant comfort or sense of well-being; the extent to which they are able to maintain reasonable physical, emotional and intellectual function; and the degree to which they retained their ability to participate in valued activities with the family, in the workplace, and in the community" (p. 344, Wenger & Furberg,1990). With cognitive appraisal being an integral part of health related quality of life, this particular type of quality of life is typically evaluated using a combination of well-being and satisfaction measures (Boswell, Dawson & Heininger, 1998; Kannisto, Merikant, Alaranta, Hokkanen & Sintonen, 1998; Shumaker, Anderson & Czajkowski, 1990). Thus, in providing an indication of the effects of the interaction between perceived physical and psychological status, these subjective measures are a valuable tool for furthering an understanding of the impact of chronic pain in the SCI population.

In realizing that subjective well-being can provide a broad indication of the impact of disability on the lives of individuals with SCI, subjective well-being assessment has gained increasing interest from researchers and health professionals alike (Clayton & Chubon, 1994). From these assessments it has been determined that when compared to the population at large, individuals with SCI report lower life satisfaction in many health-related quality of life domains (Crewe, 1980; Dijkers 1996, 1997, Fuhrur et al., 1993; Lundqvist, Siosteen, Blomstrand, Lind & Sullivan, 1991; Kannisto & Sintonen, 1997; McColl et al., 1999; Westgren & Levi, 1998; Post et al., 1998). Of the many factors contributing to health-related quality of life, pain has been identified as an important determinant (Stensman, 1994). In a cross-sectional study of 320 individuals with SCI, neuropathic pain was related to lower health-related quality of life scores on a self-administered questionnaire (Westgren & Levi, 1998). Similarly, Lundvist and colleagues (1991) reported that pain was the only complication associated with SCI to be related to lower life-satisfaction scores. From this correlational evidence, it is clear that there is a significant negative relationship between pain and subjective well-being.

The existence of a relationship between pain and subjective well-being has important implications for pain reduction interventions. Firstly, this negative relationship provides strong justification for the implementation of effective pain reduction strategies to improve the quality of life of individuals in the SCI population (Clayton & Chubon, 1994). By reducing pain, subjective well-being can be enhanced. Secondly, in demonstrating that individuals' subjective well-being is reflective of the severity of the pain that they are experiencing, subjective well-being can act as a useful index for evaluating the effectiveness and efficiency of pain reduction interventions (Boswell et al., 1998; Clayton & Chubon, 1994; Dijkers, 1996; Kannisto et al., 1998; Kannisto & Sintonen, 1997). Thus, when testing pain reduction interventions, it is suggested that measures of subjective well-being be used as an endpoint to determine the effectiveness of the interventions.

1.6 Establishing the Framework for the Development of an Intervention to Reduce Pain and Improve Physiological, Psychological and Subjective Well-Being

It has been clearly established in the existent research that chronic pain is prevalent in the SCI population. Furthermore, the potentially devastating effects of chronic pain on multiple physical and psychological aspects of a pain sufferer's life have been identified. Given the centrality of pain in the lives of individuals with SCI, efforts are needed to reduce pain and in turn, to improve psychological (e.g., stress and depression) and subjective well-being (e.g., health related quality of life). However, in order to design an intervention that both reduces pain and increases psychological and subjective well-being, a framework linking all 3 variables is needed.

Using the biopsychosocial perspective as a foundation, a conceptual model of the chronic pain process has been proposed (Mayer & Gatchel, 1988). In this cyclical model, depicted in Figure 1, the relation between pain and psychological well-being is described. Typically, for individuals with chronic pain, the chronic pain process is initiated by physical changes attributable to the injury (Gatchel, 1996). According to Mayer and Gatchel's Conceptual Chronic Pain Process Model, these physical changes can alter the pain threshold, leading to an exacerbation of pain symptoms. The presence of prolonged pain can cause an increase in psychophysiological stress and tension, thus producing additional distress and emotional changes. Emotional changes, in turn, can lead to a disruption in activities of daily living. Reduced levels of daily activity can ultimately feedback and negatively affect physical functioning and change.

As well, it has been suggested that the cycle can work in the reverse direction. Physical changes related to the injury and their after-effects (e.g. disruption of activities of daily living) can have negative consequences for emotional well-being. Emotional changes can elicit emotional distress and can lead to an increase in stress and tension. Greater psychophysiological stress can substantially affect pain threshold and exacerbation and once again, ultimately feedback and affect physical functioning and change.

This model is only a conceptual model and has not been empirically tested. Thus, from a research perspective, it requires further development and validation. However, being one of the few models describing the chronic pain process, it could be of great value to people interested in developing interventions. Specifically, by suggesting possible mechanisms by which pain and emotion are changed, health practitioners will be able to use this model as a framework for designing intervention strategies. According to this model, an intervention that alters the pain threshold by means of either a change in physical functioning or a reduction in stress should in turn improve psychological and subjective well-being. Of further benefit, through the application of this model for the development of pain reduction interventions, initiatives can be taken to test this model empirically and to advance research regarding the chronic pain process.

1.6.1 Exercise as a potential intervention strategy

From Mayer and Gatchel's model, it has been suggested that an intervention that leads to physical change should in turn lead to a reduction in pain threshold and consequently lead to a change in reported stress and psychological well-being. Many of the current pain reduction interventions are unidimensional and only focus on a single aspect of this model. For example, medical interventions, such as the prescription of pain medication, is a method that creates physical change by targeting pain reduction (Ragnarsson, 1997), but which completely ignores the psychological aspects of pain. Another pain management strategy is behavior therapy. In this type of therapy, individuals are taught cognitive and behavioral strategies to manage pain symptoms. The focus of this type of intervention is largely on the psychological components of pain and ignores physical change (Haythornthwaite & Benrud-Larson, 2000; Umlauf, 1992). Targeting both the psychological and physiological aspects of pain could maximize the potential for an intervention to decrease pain.

Exercise is one intervention strategy that provides an opportunity for both physical change and psychological change as either antecedents or consequences of pain reduction. A vast body of research describing the direct effects of exercise on each of the main constructs of Mayer and Gatchel's model exist. That is, the effects of exercise on psychological and physiological well-being are well documented (American College of Sports Medicine, 1995). However, exercise as a catalyst for triggering change in the relationships among constructs, as illustrated in the model, has not been examined empirically. Therefore, the purpose of the current study is to conduct an empirical examination of the effects of exercise on the relationships predicted in the Chronic Pain Process Model. Using the Chronic Pain Process Model as a framework, the objective of the current randomized controlled trial is two-fold: 1) to examine the effects of a 9-month aerobic and resistance training program on perceived pain and physical and psychological well-being (the constructs of the Chronic Pain Process Model) and 2) to examine the relationships between these variables as a means of gaining an understanding about the mechanism of exercise-induced change in the outcome variables (e.g., pain, physical, psychological and subjective well-being).

1.6.2 The steps for testing mediation

With the second objective of the current study being to establish the mechanism of exercise-induced change in pain and physical and psychological well-being, it is necessary to outline how these relationships will be tested. Firstly, when testing for mediation, the two variables of interest- in this case, exercise and the mediating variable (e.g., physical function or pain) - must be related to a third outcome variable (e.g., psychological well-being). Secondly, according to the mediational model, controlling for mediating variables should significantly decrease the observed relation between exercise and the outcome variable (e.g., psychological well-being; Baron & Kenny, 1986). The existing research on the effects of exercise on physical change, pain and psychological well-being is primarily descriptive, yet provides strong evidence of the relationships between exercise and these outcome variables. Reviewing this research will provide insight into the nature of the relationship between exercise and the mediation and outcome variables - the first step of mediation. Further, the gaps and limitations of the existent research will be identified and will shape the design of the current study.

1.7 The Relationship Between Exercise and Physiological Well-Being in Individuals with SCI

Increased muscular strength and improved cardiovascular function are only a few of the well-documented benefits associated with regular physical activity in the able-bodied population (U.S. Dept. of Health & Human Services, Surgeon General's Report, 1996). Because many of life's daily activities for individuals with SCI are physically taxing (e.g. transfers, wheeling up a ramp to enter a building; Janssen, van Oers, Rozendall, Willemsen, Hollander & van der Woude, 1996), the physical improvements afforded by exercise participation are of particular benefit for individuals with SCI. Indeed, in a qualitative assessment of the benefits derived from participation in a regular physical activity program, mobility impaired adults reported that the physical benefits associated with exercise improved functional status and ability to perform activities of daily living (Maher, Kinne & Patrick, 1999).

The benefits of participation in physical activity for individuals with SCI have also been described quantitatively (Noreau, Shepard, Simard, Pare & Pomerleau, 1993). The association between physical fitness, physically active leisure and disability was tested in 73 paraplegics and 50 tetraplegics. In this cross-sectional study, indices of fitness included body mass index, peak oxygen intake on an arm crank ergometer test and tests of muscle strength and endurance. The Godin Leisure Time Questionnaire (Godin & Shepard, 1985) was used to assess active physical leisure and the Activities of Daily Living Modified Barthel Index (Granger, Albrecht & Hamilton, 1979) was used to assess components of disability including mobility and self-care. Correlaional analyses revealed that aerobic fitness and arm muscle strength were positively related to functional ability scores on the Barthel Index. This relationship gives indication that physical function outcomes can be used as an indirect indicator of physiological change. Thus, from a research design perspective, if appropriate, researchers might choose to use less costly, time consuming and intrusive subjective measures of physical function as indication of physiological change rather than using physically taxing, objective measures of physical fitness such as VO_2 max tests.

Of further interest, the level of the lesion moderated the relationship between physical fitness and physical function (Noreau et al., 1993). Stronger correlations between fitness variables and Modified Barthel Index scores were observed for tetraplegics compared to the correlations observed for paraplegics. Similarly, the relationship between physically active leisure and functional ability was moderated by lesion level. A significant difference in Mobility Barthel Index scores between the highest and the lowest quartiles of leisure activity in participants with quadriplegia was noted but not for participants with paraplegia. These findings suggest that the functional ability of those with high level lesions might be improved through a vigorous physical activity program. Failure to find a relationship between physical activity and physical function for paraplegics was attributed to the poor sensitivity of the Mobility Barthel Index to detect small improvements in functional ability among the participants with paraplegia.

In a more recent correlational study that used an alternative, more sensitive measure of physical functioning, the Craig Handicap Assessment and Reporting Technique (CHART; Whiteneck, Charlifue, Gerhart, Overholser & Richardson, 1992b) it was determined that physical activity as measured by the Godin Leisure Time Questionnaire (Godin & Shepard,1985) was associated with physical functioning for both tetraplegics and paraplegics (Manns & Chad, 1999). Yet, as in the previous study, the correlation coefficient was larger for tetraplegics (r=.69) than for paraplegics (r=.46). Taken together, these two studies demonstrate that physical activity is a positive correlate of physical functioning, giving indication that participation in active physical leisure might help to improve physical function. Lastly, these studies illustrate that when evaluating the relationship between physical function and physical activity in individuals with SCI, lesion level must be taken into consideration.

1.8 The Relationship Between Exercise and Chronic Pain in Individuals with SCI

Recent research suggests that exercise is a potent treatment modality for reducing pain symptoms among a variety of chronic pain populations (Sandstrom & Keefe, 1998;

Rodriquez, Bilkey & Angre, 1992; Ettinger, 1998; Rossy, Buckelew & Dorr, 1999; Ragnarsson, 1997). For example, the pain reducing effects of exercise were clearly exhibited in the Fitness Arthritis and Seniors Trial (FAST), a well conducted randomized control trial of older adults suffering from knee osteoarthritis (Ettinger et al., 1997). Knee osteoarthritis is a condition in which chronic pain is recognized as a major feature (Davis, Cortez & Rubin, 1990). With 439 older adults with knee osteoarthritis participating in the study, it was determined that compared to an education-control group, the older adults who participated in 3 exercise sessions a week for 18 months reported a decrease in the severity of their pain over the course of the intervention. Furthermore, it was determined that participation in either aerobic- or resistance-training reduced pain and that neither form of exercise had negative effects on disease progression. Positive findings such as these indicate that exercise can reduce pain without exacerbation of disease symptoms. Consequently, exercise has begun to be recommended frequently as a strategy for pain management in this chronic pain population (Hochberg et al., 1995).

It has been suggested that exercise is a suitable intervention for pain reduction in individuals with SCI as well (Ragnarson, 1997). However, there is a dearth of experimental evidence indicating the efficacy of exercise as a pain reduction strategy for this population. In one of the few studies using exercise as a strategy for reducing pain in individuals with SCI, it was found that a 6-month, home-based program of resistance exercises and stretches had no significant treatment effect on self-reported shoulder pain in wheelchair users (Curtis et al., 1999b). A sample of 42 wheelchair users, 35 of who had a SCI, were included in this study. Prior to being assigned to either the treatment or control group, all participants completed baseline measures. Demographic information, the presence and location of shoulder pain, the presence of other upper extremity pain and treatment received for shoulder pain were assessed. Pain during the performance of activities of daily living was described using the Wheelchair User's Shoulder Pain Index (WUSPI; Curtis et al., 1999a), a self-report questionnaire. The 21 participants assigned to the treatment group attended a 60 minute educational session where they were instructed in five shoulder exercises, two static stretching exercises and three resistive strengthening exercises. Performance was monitored by a bi-weekly phone call. Participants assigned to the control group maintained their usual level of activity. At 2, 4 and 6 months into the program, questionnaire data were collected once again.

From the descriptive information, it was determined that 75% of all participants reported a history of shoulder pain and 50% of the participants reported shoulder pain upon entering the study. Interestingly, after completing 2-months of the intervention, a trend indicating that the participants in the treatment group reported greater pain than at baseline was observed. Nonetheless, at the 6-month follow-up period, a 39.3% mean decrease in WUSPI scores from baseline was reported for participants in the treatment group. In contrast, a 2.5% mean decrease in WUSPI scores from baseline was reported for control participants. Using a repeated measures ANOVA, a significant effect for time was found. The treatment main effect and the time-treatment interaction, however, were not significant. It was concluded that these results supported the overall effectiveness of the exercise and stretching protocols in the reduction of shoulder pain in individuals with SCI.

This failure to find significant effects for the intervention, even though there was a much larger mean percent decrease in the treatment group compared to the controls, can be attributed to the statistical techniques used to compare group scores. In using repeated measures ANOVAs, the statistical analyses did not account for differences between the groups in baseline WUSPI scores. Although between-group baseline scores were not significantly different, the WUSPI mean score and standard deviation for the treatment group (M= 23.3, SD=26.2) was nearly twice that of the control group (M=12.1, SD=13.3). The between groups variability may have diminished the likelihood of detecting a treatment effect. The impact of between-group differences could have been attenuated by using baseline scores as a covariate. Such statistical techniques could have increased the power of the analyses and treatment effects might have been detected (Pedhazur, 1982).

Further limitations of the shoulder pain study included the physical characteristics of the participant sample, the exercise prescription and the program monitoring technique. With regards to the sample, the possible range of scores on the WUSPI was 0-150. At baseline, the mean of the WUSPI scores was a 17.1(SD=21.3). This low sample mean indicates that there were many individuals who reported very little pain to begin with. Thus, it is possible that failure to find significant effects for the intervention is the result of a floor effect for WUSPI scores. Another possibility is that exercise is most effective at reducing pain in people who have more severe pain than the level reported by this sample. Also, unlike the study of older adults with knee osteoarthritis who exercised 3 times a week for an hour each time for 18-months, the exercise prescription in this study was not very intense and lasted only 6-months. It is possible that the exercise prescription was not vigorous enough and/or long enough to elicit the physical changes necessary to reduce pain. Furthermore, participants in the shoulder pain study received only one 1-hour instructional session and bi-weekly telephone follow-ups. Compared to the aforementioned knee osteoarthritis study that monitored the participant's exercise program for 3 months in an exercise facility before implementing a closely monitored home-based exercise program (Ettinger et al, 1997), the exercise program monitoring in the shoulder pain study was not very extensive. With little monitoring, it is possible that unknown to the researchers, the exercisers in the shoulder pain study were either doing the exercises incorrectly or were not adhering to the protocol. Nonetheless, even with these statistical and design limitations, this study does make an important contribution to research in exercise rehabilitation. This study gives indication that over the long-term, exercise does not exacerbate pain symptoms and that there is a trend for long-term involvement in exercise to lead to a decrease in shoulder pain for wheelchair users, including individuals with SCI.

1.9 Changes in Physiological Well-Being as a Potential Mediator of Exercise-Induced Reductions in Pain

According to Mayer and Gatchel's conceptual model, changes in pain threshold are preceded by physical change. In congruency with this model, it follows that exercise-induced changes in pain should be mediated by exercise-induced physical changes. With existent research being primarily descriptive, a test of this particular relationship has not been undertaken. The existent literature does, however, provide strong correlational support for the first condition in a mediating variable framework – specifically that the two predictor variables, exercise and physical change, are related to one another as well as to the third outcome variable, pain. With correlational evidence serving as a solid foundation for mediator change studies, research must begin to move to the next stage - the investigation of mediated variable relationships.

Only a few studies have used a mediating variable framework to examine the relationship between physical change and pain in an exercise intervention. In a study conducted in conjunction with the FAST study (Ettinger et al., 1997), the mediating variables contributing to physical performance on a stair climb task were assessed (Rejeski et al., 1998). It was found that after 18-months of either aerobic or resistance training thrice weekly, participants with knee osteoarthritis reported exercise-induced changes in pain which in turn induced changes in stair climb time. This study is one of the first to examine the mechanisms of pain and function-related change associated with exercise. In the FAST study, the relationship between pain and physical change was only tested in one direction; changes in pain mediated changes in physical function. It is also possible that changes in physical function mediated changes in pain. However, this reciprocal relationship, was not tested in this study yet should be tested in future studies as it is tenable (cf. Mayer & Gatchel, 1988).

1.10 The Relationship Between Exercise and Psychological Well-Being in Individuals with SCI

The second purpose of the current study is to examine pain as a mechanism of exercise-induced change in psychological well-being. Similar to the research on the mechanism of physical function and pain, there is little research on the mediators of exercise-induced changes in psychological well-being in people with SCI. With a dearth of research specifically focussing on exercise in individuals with SCI, evidence regarding the direct effects of exercise on psychological well-being must be drawn from studies involving able-bodied individuals. To understand the potential mediating role of pain in the relationship between exercise and psychological well-being, findings from other chronic pain populations will be reviewed.

1.10.1 The relationship between exercise and stress

1.10.1.1 The relationship between exercise and stress in able-bodied and chronic pain populations

An area of research that has received a great deal of attention is that examining the potential of exercise to reduce stress and anxiety and to influence stress reactivity. It has been concluded in several extensive meta-analyses that exercise has anxiolytic effects (Biddle, 1995; Crews & Landers, 1987; Petruzzello, Landers, Hatfield, Kubiz & Salazar, 1991; Salmon, 2001). For example, one study found that 6 weeks into a walking program, exercisers reported fewer daily hassles compared to an untreated control group (Cramer, Nieman & Lee, 1991). Moreover, a meta-analysis of effect size comparisons revealed that exercise is a particularly effective strategy for stress management in individuals who have a stressful lifestyle (Long & van Stavel, 1995). These findings have important implications for individuals who suffer from chronic pain and who have an elevated stress level as a result of their physical condition.

For example, among people with fibromyalgia, a non-articular rheumatic disease with symptoms including pain and tender points throughout the body (Wolfe et al., 1990), elevated levels of psychological distress are often associated with fibromyalgia symptoms (Hudson, Hudson, Pliner, Goldberg & Pope, 1985). In a 2-year randomized control trial comparing the effectiveness of biofeedback/relaxation, exercise, and a combined program of exercise and biofeedback for the treatment of fibromyalgia, intervention conditions that included an exercise component were the only conditions that resulted in a long-term reduction in psychological distress (Buckelew et al., 1998). During the first phase of this study, 119 participants with fibromyalgia attended a weekly instruction session and were encouraged to practice their intervention skills two additional times each week. Participants in the exercise group and the combined treatment group received instruction and participated in flexibility, strengthening and aerobic training exercises during these sessions. Participants in the biofeedback/relaxation and the combined treatment group received instruction in breathing and relaxation techniques. A variety of physiological and psychological measures including, psychological distress using the Symptom Checklist-90-Revised (Derogatis, 1977), were administered pre-treatment, immediately post-treatment and 3, 12 and 24 months post-treatment. Participants in all treatment groups reported immediate post-treatment decreases in psychological distress. These changes were only maintained at later follow-up assessments however, for individuals who participated in treatments that included exercise as an intervention component. Along with positive changes in psychological distress, participants in the exercise only condition simultaneously reported long-term decreases in the severity of their pain symptoms. According to Mayer and Gatchel's model, these parallel decreases in physiological distress and pain are not coincidental. Rather, a change in one of the variables precipitated a change in the other variable. This hypothesis, however, remains to be tested in a prospective study design.

1.10.1.2 The relationship between exercise and stress in individuals with SCI.

Studies examining the effects of exercise on stress management in individuals with SCI are sparse. In one of the few exercise intervention studies in which anxiety was one of the many outcome variables, exercise had no significant treatment effect on participants' anxiety levels compared to a non-exercise control group (Bradley, 1994). These null results, contradictory to findings in able-bodied and other chronic pain populations, can be partially attributed to the exercise prescription. The 33 participants in the self-selected exercise group participated in a 3-month hybrid functional electrical stimulation exercise program including isokinetic muscle training, bicycle ergometry, biofeedback, physical therapy and gait training. Although the frequency of treatment was outlined in the study (3 to 5 days a week), no indication of the exact dose of exercise was given. In the able-bodied population, it has been established that exercise has its greatest anxiolytic effects when exercise bouts are aerobic in nature and exceed 21 minutes in duration (Petruzzello et al., 1991). Thus, it is possible that the functional electrical stimulation exercise program did not elicit a strong enough cardiovascular response and/or the actual exercise stimulus was not long enough to allow participants to benefit from the stress-reducing effects of exercise. Therefore, when implementing an exercise intervention with the purpose of reducing stress in individuals with SCI, health practitioners should ensure that an adequate dose of exercise is prescribed.

1.10.2 The association between exercise and depression

1.10.2.1 The relationship between exercise and depression in able bodied and chronic pain populations

Several cross-sectional examinations of the relationships between physical activity involvement and depression have been conducted. From these studies, a strong negative relationship between level of physical activity and depression status has been established (Stephens, 1988, Thirlaway & Benton, 1992). Moreover, it has been repeatedly found that increasing the physical activity level of individuals who exhibit depressive symptoms is an effective intervention for reducing depression (Blumenthal et al., 1999; Craft & Landers, 1998). Consistent with these findings, exercise intervention studies involving chronic pain samples with coexistent depressive symptoms report a reduction in depressive symptoms following participation in a physical activity program (McCain et al., 1988).

In Buckelew and colleagues' (1998) two-phase (a 6-week intervention phase and a 2-year follow-up phase) randomized control trial of individuals with fibromyalgia, a non-significant trend indicating a decrease in the frequency of depressive symptoms was observed. It is possible that if the actual intervention that lasted only 6-weeks had been longer, this trend might have been significant. Indeed, greater relief of depressive symptoms in other samples of individuals suffering depression were more likely to result resulted following longer interventions lasting 9-12 weeks than following shorter interventions lasting 8-week or less (Craft & Landers, 1998; Salmon, 2001). Thus, when designing an exercise intervention for other chronic pain populations who report high levels of depressive symptoms, such as individuals with SCI, an exercise intervention should be at least 9-weeks in length.

1.10.2.2 The relationship between exercise and depression in individuals with SCI

In the SCI population, a relationship between physical activity status and depression similar to the relationship described in the able-bodied population has been observed. Correlational studies indicate that among people with SCI, level of physical activity is negatively correlated with depression (Coyle et al., 1993; MacDonald, Nielson & Cameron, 1987; Muraki, Tsunawake, Hiramatsu & Yamasaki, 2000). Likewise, exercise has been found to be an effective intervention strategy for reducing depressive symptoms in individuals with SCI. In a study using a pre-post experimental design, it was determined that after 32-sessions of ambulation with functional electrical stimulation, 15 participants with SCI reported a decrease in their level of depression (Guest, Klose, Needham-Shropshire & Jacobs, 1997). Due to the quasi-experimental design and the characteristics of the exercise stimulus, researchers must be cautious when interpreting the positive results of this study.

Specifically, the pre-post design with no control group is a limitation of this study. Without a control group, the conclusion that participation in the exercise program reduced depression can be challenged. It can be argued that extraneous variables such as time and interaction with therapist were the factors causing the alteration in depression. Exercise studies with a control group are needed. Additionally, in this study of the effects of ambulation on depression, it is possible that standing and walking may have a more powerful effect on psychological outcomes than more conventional forms of exercise such as aerobic and resistance training. Thus, before making a generalized statement that exercise can reduce depressive symptoms in individuals with SCI, a wider variety of types of exercise should be examined.

1.11 The Relationship Between Exercise and Subjective Well-Being

1.11.1 The relationship between exercise and subjective well-being in able-bodied and chronic pain populations

In general, physical activity/exercise is associated with improvements in various aspects of subjective well-being (Rejeski et al., 1996). Results from 1,387 respondents to a random digit dialing survey on health behaviors indicated that regular exercisers reported a greater perceived quality of life than non-exercisers (Laforge, Rossi, Prochaska, Velicer, Levesque & McHorney, 1999). Similarly, in an investigation of the relationship between physical fitness and health related quality of life in older adults, physical function was associated with many of the quality of life domains examined including energy, pain, social isolation and physical mobility (Wood et al., 1999). Interestingly, higher scores in the pain domain of the quality of life questionnaire were associated with poorer performance on an aerobic endurance test. This finding suggests that when examining the relationship between quality of life and exercise, pain is a factor that should be considered.

This relationship is not restricted to individuals in non-clinical populations (Rejeski et al., 1996). For example, the relationship between exercise and subjective well-being has been exhibited in clinical population suffering from chronic pain (Buckhardt, Mannerkorpi, Hedenberg & Bjelle, 1994; Ferrell, Josephson, Pollan, Loy & Ferrell, 1997; Gowans, deHueck, Voss & Richardson, 1999; Rejeski, Ettinger, Martin & Morgan, 1998). In Rejeski and colleagues' (1998) study involving individuals with knee osteoarthritis, participation in either aerobic or resistance training led to significantly more favorable health perceptions, a component of health-related quality of life, than attending non-exercise education sessions. What is most interesting about this finding is that knee pain mediated the effect of the exercise treatment on health perceptions. These results suggest that exercise was an effective treatment for reducing pain and reducing pain was an effective strategy for improving one dimension of quality of life. When the authors used a mediating variable framework, it was possible to not only realize that the intervention improved health perceptions but also to demonstrate how the intervention changed health perceptions (i.e., by decreasing pain). Understanding how the intervention worked provides a basis to build interventions that target the mediating factors that lead to change in the outcome variable (Baranowski, Anderson & Carmack, 1998). Few studies have used a mediating variable framework to evaluate the mechanisms of change in subjective well-being. However, a change in focus to mediational analyses would be beneficial to the development of interventions.

1.11.2 The relationship between exercise and subjective well-being in individuals with SCI

Unlike the research concerning exercise and subjective well-being in individuals with knee osteoarthritis, the research concerning exercise and subjective well-being in individuals with SCI has not been well developed. A strong base of evidence exists suggesting that exercise improves objective measures of health related quality of life (e.g., disability and handicap; Noreau & Shepard, 1995). In contrast, only a small number of studies have investigated the association between physical activity and subjective well-being (e.g. life satisfaction; Coyle et al., 1994; Manns & Chadd, 1999). The results of these studies are inconclusive. For example, in an exploratory study including 38 individuals with SCI, no relation between Quality of Life Profile (Rudman, Renwick, Rapheal & Brown, 1995) scores and fitness and physical activity were revealed (Manns & Chad, 1999). The lack of relation between activity variables and subjective quality of life was attributed to the global nature of the quality of life measure used. The Quality of Life Profile examines 9 separate domains of quality of life. Many of the domains included in the questionnaire have no direct relation to physical function (e.g., marital and financial status) so one would not expect these domains to be significantly related to physical function. Consequently, the inclusion of the non-relevant items in the quality of life measure decreases the sensitivity of the measure to detecting a significant relationship with physical function. In future examinations of the relationship between exercise and quality of life in individuals with SCI, a more specific measure of quality of life that relates to fitness outcomes, such as health related quality of life would be more appropriate.

In contrast to these null findings, correlational data from a cross-sectional study examining the association between life satisfaction and participation in leisure activities indicated that individuals with SCI who were more involved in leisure activities had greater life satisfaction than individuals who were less involved in recreation (Coyle et al., 1993). Although these findings describe a relationship more similar to that described in other non-SCI populations, they must be interpreted cautiously. The study examined the relationship between the broad category of "leisure activity" and quality of life. Although exercise and sport were a component of leisure, other activities such as volunteer activities and craft activities were included in this category. Thus, from this study it cannot be concluded that exercise alone leads to an increase in quality of life.

From these two studies it is clear, however, that a more specific assessment of the relationship between exercise and subjective well-being in individuals with SCI is required. In order to fully establish a strong relationship between these 2 variables, measures and definitions of exercise and subjective well-being are crucial. Also, it must be emphasized once again that research endeavoring to not only describe this relationship but also to identify the mechanisms leading to change in this relationship (i.e., between exercise and subjective well-being) is necessary.

1.12 Summary

Chronic pain, with its many sources, is a frequent and debilitating comorbidity of SCI. As a result of this secondary complication of SCI, pain sufferers often report a lower level of physical functioning, psychological well-being and ultimately, a reduced quality of life. Because chronic pain is so prevalent among individuals with SCI, and has so many negative effects, an intervention to reduce pain and improve physical functioning, psychological and subjective well-being is needed. Although the need is great, few effective interventions exist for pain management for individuals with SCI.

However, Mayer and Gatchel's Conceptual Chronic Pain Process Model (1988) provides a framework for the development of such an intervention. According to this conceptual model, an intervention that elicits physical change should in turn reduce pain symptoms. Consequent to a reduction in pain is a reduction in stress and an improvement in emotional status. In participant samples of able-bodied individuals, chronic pain sufferers, and people with SCI, exercise is one intervention strategy that has been shown to have a positive association with each of the constructs of this conceptual model. However, the effects of exercise on the concurrent relationships between the constructs in Mayer and Gatchel's conceptual model have yet to be examined. The purpose of the current study is to examine the predicted relationships described in Mayer and Gatchel's conceptual model and to determine the effects of exercise on these relationships. More specifically, the objective of the current study is to examine the effects of a 9-month exercise intervention on perceived pain and physical, psychological and subjective well-being. Secondly, the mediational relationships between these variables, as predicted by the Chronic Pain Process Model, will be tested.

As one of the first theory-based examinations of the effects of exercise on psycho-social variables in individuals with SCI and with the concurrent relationships of the Chronic Pain Process Model not having been previously tested in the context of an exercise intervention, the current study will examine each of the relationships described in the Chronic Pain Process Model separately. Testing each relationship separately through mediational analyses rather than testing the model in its entirety using structural equation modeling will provide potential evidence for each individual relationship rather than for the complete model. Determining that the relationships described in the Chronic Pain Process model hold up when tested individually will serve as a basis for a future, large sample size test of the model in its entirety.

Introduction

A traumatic spinal cord injury causes structural damage to the spinal cord resulting in sensory and functional loss (Marieb, 1995). In addition to the disabling effects of SCI, individuals must also contend with many secondary impairments (e.g., urinary tract infections, pressure ulcers and chronic pain [Gerhart et al., 1992; Noreau et al., 2000]). However, due to the catastrophic, life-threatening nature of the injury, little appreciation is given to the extent and nature of these secondary conditions. Consequently, the comorbidities associated with SCI are poorly understood and effective management strategies for each comorbidity require further development (Noreau et al., 2000).

Chronic pain, the persistence of pain symptoms for a minimum of 3 months (Altmaier et al., 1993), is one such comorbidity of SCI for which there is limited clinical appreciation (Ravenscroft et al., 1999). An estimated 18-94% of people with SCI report chronic pain symptoms (Lamid et al.,1985; Mariano, 1992; Rintala et al., 1998; Siddall et al., 1997, 1999), 30-40% of who report that the pain is severe and/or disabling (Loubser & Donovan, 1996; Nepomuceno et al., 1979; Ravenscroft et al., 2000; Stromer et al., 1999; Summers et al., 1991; Sved et al.,1997). Of further concern, pain has been reported to affect physical function and handicap beyond levels attributable to the SCI injury per se (Lamid et al., 1985; Rintala et al., 1998).

As a central concern for individuals with SCI, the debilitating symptoms of chronic pain are often a hindrance to physical function and psychological well-being

(Davidoff et al., 1987; Ravenscroft, 2000; Rintala et al., 1998; Wegener & Elliot, 1992). In particular, in the SCI population, pain has been found to interfere with activities of daily living (Dalyan et al., 1999; Kaplan et al., 1962; Lamid et al.,1985; Nepomuceno et al., 1979; Rose et al., 1988) and to be associated with elevated levels of stress (Cohen et al., 1983; Rintala et al. 1998), anxiety (Cohen et al., 1988; Summers et al., 1991; Rintala et al., 1998; Richards, 1980) and depression (Boekamp et al., 1996; Cairns et al., 1996; Elliott & Frank, 1996; Rintala et al., 1998; Mariano, 1992; Nepomuceno et al, 1979; Summers et al., 1991). Because of the negative impact of pain on the lives of its sufferers, individuals with SCI and chronic pain generally have a lower quality of life than individuals with SCI who are pain-free (Anke et al., 1995; Lundvist et al.,1991; Westgren & Levi, 1998).

According to Mayer and Gatchel (1988), the negative effects of pain on multiple life domains are the result of a cyclical chronic pain process as depicted in Figure 1. It is proposed that the chronic pain process is initiated by physical changes attributable to the injury. These physical changes can alter the pain threshold leading to an exacerbation of pain symptoms. The presence of prolonged pain can cause an increase in psychophysiological stress and tension, thus, producing additional distress and emotional changes. Emotional changes in turn can lead to a disruption in activities of daily living. Reduced levels of daily activity can ultimately feed back and negatively affect physical function and change. As well, it has been suggested that the cycle can work in the reverse direction. Physical changes related to the injury and their after-effects (e.g. disruption of activities of daily living) can have negative consequences for emotional well-being.

Emotional changes can elicit emotional distress and lead to an increase in stress and tension. Greater psychophysiological stress can subsequently affect pain threshold and exacerbation and once again, feed back and affect physical function and change. This model of the chronic pain process makes good conceptual sense, yet, having never been tested experimentally, empirical support for it is lacking. To test the validity of the Chronic Pain Process Model and to advance research regarding the chronic pain process, it would be useful to examine the validity of its predictions within the context of a pain reduction strategy.

With the chronic pain process describing a cyclical relationship between physical and psychological symptoms, the model implies that targeting both the psychological and physiological correlates of pain might be a strategy to maximize the potential for an intervention to decrease pain. Exercise is one intervention strategy that provides an opportunity for both physical change and psychological change as either antecedents or consequences of pain reduction. Indeed, a vast body of research exists describing the effects of exercise on pain and physical and psychological well-being (constructs of the Chronic Pain Process Model) in chronic pain populations exists (Ettinger, 1998; Ragnarsson, 1997; Rodriquez et al., 1992; Rossy et al., 1999; Sandstrom & Keefe, 1998). For example, in a study of individuals with knee osteaoarthritis, those who participated in regular exercise over an 18-month intervention reported less pain, improved physical function and greater perceived health than non-exercising control subjects (Ettinger et al., 1997). Similarly, in an exercise intervention study of individuals suffering from the painful symptoms of fibromyalgia, people who participated in the intervention conditions involving exercise reported reductions in pain and psychological distress (Buckelew et al., 1998).

Although there is support for the effects of exercise on pain and physical and psychological well-being in a variety of other populations, such effects have been largely understudied in the SCI population. The few exercise studies involving individuals with SCI provide very preliminary evidence that exercise is a method for reducing pain (Curtis et al., 1999b) and improving physical function (Noreau et al., 1993) and psychological well-being (Guest et al., 1997; Muraki et al., 2000; Wise, 2000). To date however, the proposed effects of exercise in individuals with SCI have not been systematically examined using a randomized controlled experimental design. Further, the effects of exercise on the relationships between pain and physical and psychological well-being predicted by the Chronic Pain Process Model have not been investigated in the SCI population. Therefore, the purpose of the current study was to conduct a randomized controlled trial examining 1) the effects of exercise on perceived pain and physical and psychological well-being and 2) the relationships between these variables.

Drawing from evidence suggesting that for individuals with SCI, physical activity is associated with greater physical function (Noreau et al., 1993; Manns & Chad, 1999) and psychological well-being (Guest et al., 1997; Muraki et al., 2000; Wise, 2000) and less perceived pain (Curtis et al, 1999b), three hypotheses were formulated for the first study objective. The hypotheses were as follows: 1) participants in a 9-month, twice-weekly aerobic and resistance exercise program (exercise participants) would report greater improvements in physical well-being, operationalized as satisfaction with physical function and appearance, than the non-exercising control subjects, 2) exercise participants would report a greater decrease in perceived pain than the non-exercising control subjects and 3) exercise participants would report greater improvements in psychological well-being than the non-exercising control subjects.

The hypotheses for the second study objective, to examine the relationships between perceived pain and physical and psychological well-being, were developed in accordance with predictions of the Chronic Pain Process Model. More specifically, it was hypothesized that: 4) the effects of exercise on perceived pain would be mediated by exercise-induced changes in physical well-being, 5) the effects of exercise on stress would be mediated by exercise induced changes in perceived pain, 6) the effects of exercise on emotional well-being, operationalized as depression, would be mediated by exercise-induced changes in stress 7) the effects of exercise on physical well-being would be mediated by exercise-induced changes in depression.

Although the conceptual pain process model indicates that the relationships between constructs are bi-directional, the mediational relationships were examined only in one direction in order to minimize the likelihood of Type 1 error (testing the model bi-directionally would have required double the number of statistical comparisons). The selected direction was based on the empirically founded, cognitive-motivational-relational theory of emotion in which stress is clearly established as a mediator of emotion (Lazarus, 1991,1993; Lazarus & Folkman, 1984). Determining the direction of the stress-emotion relationship dictated the direction of the three remaining relationships.

As one of the first randomized controlled exercise interventions for individuals with SCI, it was determined that in addition to the effects of exercise on physiological and psychological outcome variables and the relationship between variables following exercise, the overall effectiveness of the intervention as a pain management strategy should be evaluated. It has been demonstrated that for individuals with SCI, subjective well-being, the subjective component of quality of life (e.g., overall life satisfaction, perceived physical and psychological functioning), is reflective of the severity of the pain they are experiencing. Hence, subjective well-being can act as a useful approach for evaluating the effectiveness and efficiency of a pain reduction intervention (Boswell et al., 1998; Clayton & Chubon, 1994; Dijkers, 1996; Kannisto et al., 1998; Kannisto & Sintonen, 1997). Thus, a third objective of the current study was to determine the effectiveness of the exercise intervention using subjective well-being as an indicator of treatment efficacy. Evidence from the able-bodied and other chronic pain populations indicates that exercise improves quality of life (Laforge et al., 1999; Rejeski et al., 1998; Rejeski et al., 1996; Wood et al, 1999). Therefore, it was postulated that: 8) after the exercise intervention, individuals who exercised would have a more positive change in subjective well-being than non-exercising individuals and 9) the effects of exercise on subjective well-being would be mediated by exercise induced changes in perceived pain, as an indication of the efficacy of exercise as a pain-reduction strategy.

Method

Participants

Inclusion criteria required participants to be at least 18 years of age, diagnosed with a traumatic SCI, a minimum of one year post-injury and medically cleared to exercise. Contraindication for participation 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, for the non-exercising control group, participation in a supervised exercise program over the course of the trial. Individuals over the age of 45 were required to pass a Stage 1 exercise tolerance test in order to be considered eligible for participation in the study.

Candidates for the study were recruited from local associations and health care programs for individuals with SCI. Media advertisements were also circulated in the newspaper and at consumer resource centers. Eligible respondents were matched for years post injury (using classification categories ≤10 years post injury and >10 years post injury) and relative mortality risk (using a scale developed by Coll and colleagues [1998] to account for the level and completeness of the SCI). Within each matching, participants were randomly assigned to either an exercise or a control intervention condition at a 2:1, exercise to control, ratio.

Measures

The internal consistency of each non-weighted, multi-item scale was evaluated at all 4 measurement periods. Adequate internal consistency was demonstrated when

Cronbach alpha values exceeded .70 (Nunnally, 1978). All of the alpha coefficients calculated are included in Table 1.

Participant Description

Impairment. Degree of impairment was determined using the ASIA Impairment Scale (American Spinal Injury Association, 1992). Based on the results of a neurological assessment, individuals' level of impairment was graded on a five-point scale, A-E. Classification was indicative of completeness of the injury (e.g., A= complete, B-D= incomplete, E= normal) and function below the level of the lesion (B= sensory function but no motor function, C= motor function preserved with a majority of major muscle groups partially innervated, D= motor function preserved with majority of muscle groups fully innervated). The scale is widely used as a standard measure of impairment (American Spinal Injury Association, 1992).

Disability. The participants' level of disability was described using the Functional Independence Measure (FIM; Hamilton et al., 1987). The degree of independence each individual had for 13 activities of daily living was assessed on a 7-point scale (7= complete independence, 1=total assistance). The areas of function examined included: self-care, sphincter control, mobility and locomotion. The sound psychometric properties of the FIM of the have been extensively demonstrated (Dodds, Martin, Stolov & Deyo, 1994; Granger , Cotter, Hamilton, Fiedler & Hens, 1993; Hamilton, Laughlin, Granger & Kayton, 1991; Linacre, Heinemann, Wright, Granger & Hamilton, 1994)

Handicap. The Craig Handicap Assessment and Reporting Tool (CHART; Whiteneck et al., 1992b) was used to quantify the extent of physical and social handicap experienced by each participant. In the current study, the weighted scores were calculated for four of the CHART handicap domains (physical independence, mobility, occupation and social integration). Having been widely used in clinical outcome measure for individuals with SCI, the validity and reliability of the CHART for use with individuals with SCI has been well documented (Whiteneck et al., 1992b; Fuhrer et al., 1993).

Intervention Outcomes

Perceived pain[I]. Pain perceptions were measured using the 2 pain items from the Short-Form 36-Item Health Survey (SF-36 [Ware & Sherbourne, 1992]). Using a 6-point scale, participants rated how much pain they experienced and how much pain interfered with normal work in the last 4 weeks (1=none/not at all, 6=very severe/extremely). Consisting of only 2-items, Chronbach's alphas could not be calculated for the SF-36 Bodily Pain subscale. However, the subscale is widely used and has been shown repeatedly to be a reliable and valid measure of pain in a variety of patient populations (e.g., McHorney, Ware & Raczek, 1993).

Physical well-being. Physical well-being was assessed using Reboussin and colleagues' (2000) 9-item body satisfaction questionnaire, along with a 10th item we included to measure satisfaction with arm muscle strength. This item was included because arm muscle strength is a very important aspect of physical function for this wheelchair-using population (Curtis et al., 1999b). Items were rated on a 7-point satisfaction scale ranging from –3 (very dissatisfied) to +3 (very satisfied). This scale, developed for use in an adult able-bodied population, has been shown to measure 2 dimensions of physical satisfaction--satisfaction with body function and satisfaction with body appearance. Both the 6-item body function and the 4-item body appearance subscales showed adequate internal consistency in the present study ($\alpha > .70$).

Psychological Well-Being

Stress. The 14-item scale Perceived Stress Scale (PSS [Cohen et al., 1983]) measured the frequency of stressful encounters experienced within a participant's life over the past 4 weeks. Items were rated on a 6-point frequency scale ranging from 1 (all of the time) to 6 (none of the time). The reliability and validity of the PSS as a means for examining stress in the etiology of disease and as an outcome measure of the level of daily stress experienced by an individual has been shown (Cohen et al., 1983). The internal consistency of the PSS was adequate at all measurement points as indicated by the Cronbach alpha coefficients ($\alpha > .70$).

Depression. The Centre for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), a measure of depressive symptomology designed for use in community samples, was used. Respondents were asked to indicate how often, over the past week, they experienced each of the 20 symptoms described in the CES-D. Responses were made on a 4-point scale ranging from 0 (rarely or none of the time) to 3 (most or all of the time). Scores on the scale can range from 0-60. Scores of 16 or higher are generally considered to indicate an increased risk of experiencing clinical depression (Fuhrer et al, 1993). The CES-D has demonstrated a high degree of reliability and validity (Radloff, 1977). For the current study, adequate internal consistency was demonstrated ($\alpha > .70$).

Subjective Well-Being

In the current study, the subjective well-being measure was a composite score of two moderately correlated (r>.42) measures of subjective well-being: the quality of life and life satisfaction measures described below. Scores from these 2 scales were standardized and summed together to create a single measure of subjective well-being. In combining the two scales, the number of required statistical comparisons was reduced and consequently, the likelihood of a Type 1 error was minimized.

Quality of life. Satisfaction with fundamental needs of daily living were evaluated using the 11-item Perceived Quality of Life Scale (PQOL; Patrick, Danis, Southerland & Hong, 1988) with 4 additional items: how often you get out of the house, the amount of walking/wheeling you do, your level of sexual activity or lack of sexual activity and the amount and kind of sleep you get. These items, often included in other measures of HRQL, reflect factors associated with quality of life for people with SCI (Gerhart et al., 1992). Thus, to increase the content validity of the scale for the target population, these items were added. Participants indicated their responses on a 7-point satisfaction scale with verbal labels ranging from very dissatisfied (1) to very satisfied (7). High internal consistency for the PQOL scale has been shown for individuals with chronic medical conditions (Patrick et al., 1988). For the current study, Cronbach alphas were indicative of adequate internal consistency (α >.70).

Life satisfaction. The measure of overall life satisfaction was derived from Cantril's Ladder of Life Satisfaction (Cantril, 1965). Participants rated their overall life satisfaction for the past 4 weeks on a 9-point scale schematically represented as a 9-rung ladder (1=worst possible life, 9=best possible life). This measure has been used with many chronic populations and has demonstrated high test-retest reliability and discriminant validity (Molzahn, Burton, McCormick, Modry, Soetaet & Taylor, 1997; Stenten, 1991).

Procedure

Prior to randomization, all participants completed the experimental measures described above. A research assistant presented the questionnaire items verbally to each participant and recorded his/her responses. An interview format was used because not all of the participants were able to use pen and paper independently. Additionally, during this initial testing session, physiological parameters were assessed for a concurrent study. These physiological variables will not be discussed in this paper.

All pre-test measures were repeated at approximately the 3, 6 and 9 month points of the intervention. To ensure that all exercisers had the same amount of training at the post-test, an absolute time measure was used to schedule testing sessions. That is, following each measurement period, the preceding series of measures were taken once the exercise participant had completed 22 to 24 training sessions.

Intervention

In the wait-list control condition, participants were instructed to continue on with their normal activities and requested to refrain from starting a regular exercise routine for the duration of the study. Upon completion of the study, these participants were invited to use the exercise facilities twice weekly.

In the exercise condition, participants trained twice weekly for 9 months at the McMaster Centre for Health Promotion and Rehabilitation. Throughout the training period, participants exercised in small groups (i.e. 3-5 people). At each exercise session, each participant was supervised by an able-bodied volunteer who provided exercise assistance and safety tips. Training sessions included a 5-min. stretching phase, 15-30 of aerobic arm ergometry exercise and 45-60 minutes of resistance exercise. Initially, participants trained on the arm ergometers at 70% of the maximum effort achieved during baseline testing. As the participant noted decreases in perceived exertion and/or heart rate while performing arm ergometry, the workload and/or the duration of the aerobic activity was progressively increased.

Resistance training was carried out using wall pulley exercises, free weights and Equalizer (Red Deer, Alberta) weight machines. Exercises were grouped into categories, according to the body part being trained. These categories included abdominals, back, chest, shoulder, biceps, triceps, wrist and legs. At each training session, participants completed 2 exercises from each of these categories, with the exception of the abdominal category, from which they completed one exercise. If a participant had a neural or physical limitation causing him/her to be unable to perform any exercises with a particular muscle group, training for that group was omitted. Thus, although each training program was based on similar training principles, there was great variability among the programs to suit each individual's abilities.

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 reduce the risk of injury to the exercisers. After 8 sessions, heavier weights were used and 3 sets of 10-12 repetitions of each exercise were performed in order to maximize improvements in strength.

Statistical Analyses

All analyses were evaluated with a priori contrasts employing per comparison error rates ($p < .05$). In other words, because explicit hypotheses were established prior to the study, each test was evaluated at the .05 level without any adjustment for multiple comparisons (Keppel, 1991). Two types of demographic data were collected -- continuous and categorical. Between-group differences in demographic characteristics were assessed using independent t-tests on the continuous data and χ^2 tests for goodness of fit on the categorical data. To test for intervention effects, percent change scores for each assessment interval (i.e., 0-3 months, 3-6 months and 6-9 months) were calculated. The percent change scores for each outcome variable were submitted to separate 2 (group: exercise, control) x 3 (time: 0-3, 3-6 and 6-9 months) analyses of covariance (ANCOVA) adjusted for baseline values and with repeated measures on the last factor. As per Baron and Kenny's recommendations (1986), a series of prospective hierarchical linear regression analyses were conducted to test for mediation. For these prospective analyses, the 0-6 month percent change score for the mediator variable was used to predict the 0-9 month percent change in the outcome variable.

Results

Approximately 250 individuals with SCI in the Hamilton-Wentworth region were invited to participate in the current intervention study. Of those invited to take part in the study, only 34 individuals were interested in participating and satisfied all of the inclusion criteria (approximately 14% recruitment rate). These individuals were randomized to either the exercise (n=21) or control (n=13) group. The characteristics of the randomized participants are summarized in Tables 2 and 3. No between-group differences were observed.

Of the 34 participants randomized, 23 participants completed the study (11 exercise, 12 control). The compliance of the exercise group decreased over the intervention: 90% at 3-months, 62% at 6-months and 52% at 9-months. With the largest decrement in compliance occurring between 3 and 6-months, these compliance rates are consistent with Dishman's (1991) observation of exercise compliance in the able-bodied population. Typically in the able-bodied population, 50% of exercisers drop out within 6-months of initiating an exercise program. The common reasons for withdrawal in the current study are shown in Figure 2 and were related to illness and lack of time as a result of work, school, travel and illness. Retention of the control participants remained high throughout the intervention (defined as the number of scheduled follow-up assessments attended). One control participant withdrew immediately following randomization to the control group and 2 control participants each missed one assessment period, 1 at 3-months and 1 at 6-months. Because these latter 2 participants were missing data, they were eliminated from all repeated measures analyses. Final analysis therefore consisted of 11 exercise participants and 10 control group participants.

Intervention Effects

Table 4 presents descriptive statistics for each outcome measure (baseline, group and percent change at 0-3, 3-6 and 6-9 months) and provides a summary of the findings relating to the first purpose of the study.

Changes in physical well-being and perceived pain. In a test of hypotheses 1 and 2, separate repeated measure ANCOVAs, adjusted for baseline values, were conducted for satisfaction with physical function and appearance and perceived pain. A main effect for group reflected that exercisers' pain decreased while control subjects' pain increased, $F(1,18)= 13.94$, $p<.01$. No other effects were significant. However, for both measures of physical well-being there was a non-significant trend for exercisers to report greater increase in satisfaction with physical function, $F(1,18)= 3.22$, $p=.09$, and appearance $F(1,18)= 1.95$, $p=.18$, than controls.

Changes in psychological and subjective well-being. Separate baseline adjusted, repeated measures ANCOVAs testing hypotheses 2, 3 and 8, revealed significant differences between the exercise and control groups for all of the psychological and subjective well-being variables. Significant main effects for group on measures of stress, $F\ (1,18)=8.93$, $p<.01$, and depression, $F\ (1,18)=5.24$, $p=.03$, reflected that while exercisers had a decrease in stress and depression, control subjects had an increase in these dimensions. Similarly, a main effect for group on the subjective well-being index, $F(1,18)=11.17$, $p<.01$, reflected an increase in subjective well-being for exercisers and a decrease in subjective well-being for control subjects. Neither the main effect for time nor the time by group interaction were significant for any of these variables.

Testing for Mediation

The second objective of the current study was to examine mediators of exercise-induced change in outcome variables for a 9-month exercise intervention (refer to Appendix B for a summary of results relating to this objective). As outlined by Baron and Kenny (1986), to test for mediation, the four conditions represented in Figure 2 (Paths A, B, C and D) must be satisfied. The conditions for Path A, B and C were established through hierarchical linear regression analyses. If the first three conditions were met (Paths A-C), a fourth regression was conducted in which group was entered after controlling for the mediator. Perfect mediation occurred if, once the mediated variable was controlled, exercise no longer had an effect on the outcome variable (i.e., Path D was not significant). However, if in the final regression model exercise had an effect on the outcome but the effect was smaller than when the mediator was unaccounted for, partial mediation occurred.

Prior to conducting these regression analyses, correlations between the predictor variables were calculated to determine whether multicollinearity adversely influenced the stability of the ΔR^2 estimates. The variables being only moderately correlated with each other ($\underline{r}s < .68$), gave little indication of this problem (Pedhazur, 1982). Further, for each regression model, the variance inflation factor (VIF) for each independent variable and the equivalent statistic for the model ($VIF_{model} = 1/[1-R^2_{model}]$) were calculated. As per the recommendation of Freund and Wilson (1998), there was no evidence of strong multicollinearity because none of the VIF values (VIFs <2.6) exceeded the equivalent statistic for the corresponding model ($VIFs_{model}$>1.28).

Physical Well-Being as a Mediator of Perceived Pain

Satisfaction with physical function as a mediator of perceived pain. Included in Table 5 are the linear models testing the four conditions of mediation, paths A-D for hypothesis 4. As exhibited in Table 5, once adjusting for baseline values, group had a significant effect on perceived pain (path A) and satisfaction with physical function (path B). As for path C, once baseline perceived pain and physical function were accounted for, 0-6 month changes in physical function had a significant effect on changes in perceived pain (ΔR^2= .19, p<.05). Thus, Path C was significant. The addition of group to the model (path D) accounted for an additional 31% of the variance in 0-9 month change in perceived pain. However, as shown in Path A, without controlling for physical function, group alone explained 43% of the variance in perceived pain (p<.01). Therefore, although perfect mediation did not hold, with group accounting for less variance in perceived pain when the mediator was controlled for, the conditions for partial mediation were satisfied. Partial mediation gives indication that in addition to satisfaction with physical function, other factors are affecting exercise-induced change in perceived pain.

Satisfaction with physical appearance as a mediator of perceived pain. In a second test of hypothesis 4 (this time using satisfaction with physical appearance as an index of physical well-being), as indicated in Table 6, after adjusting for baseline values, group had a significant effect on 0-9 month changes in perceived pain (ΔR^2= .43, p<.01) and 0-6 month changes in satisfaction with physical appearance (ΔR^2= .19, p<.05). Thus, the conditions for paths A and B were satisfied. Path C however was not significant. Change in satisfaction with physical appearance was not a significant predictor of 9-month change in perceived pain ($\Delta R^2 = .16$, p=.07). Because the conditions for path C were not satisfied, the test for mediation was terminated and the model for path D was not examined. Thus, contrary to the hypothesis, satisfaction with physical appearance, an aspect of physical well-being, did not mediate change in perceived pain.

Perceived pain as a mediator of stress. Separate hierarchical regression analyses controlling for baseline values revealed that group had a significant effect on 9-month change in stress ($\Delta R^2 = .21$, p<.05) and 6-month change in perceived pain ($\Delta R^2 = .27$, p<.01). As can be seen in Table 7, the conditions for Path C were also fulfilled. Baseline adjusted change in perceived pain was a significant predictor of 9-month change in stress. In controlling for Path C, when group was entered into the linear model, group no longer had an effect on stress ($\Delta R^2 = .08$, p=.06). Thus, as postulated in hypothesis 5, all four conditions for mediation held indicating that the effects of exercise on stress were mediated by exercise-induced change in perceived pain.

Stress as a mediator of depression. Paths A and B in Table 8 indicate that group had a significant effect on baseline adjusted 9-month change in depression ($\Delta R^2 = .19$, p<.05) and 6-month change in stress ($\Delta R^2 = .23$, p<.01). Path C indicates that in controlling for baseline depression and perceived stress, changes in perceived stress at 6 months accounted for 43% of unique variance in changes in depression at 9 months (p<.001). Having established that Path C was significant, Path D was examined. In this last model, the final variable, group, contributed no additional variance to the regression model

(ΔR^2= .00, p=.66). Thus, Path D was not significant and the conditions for mediation were satisfied. As predicted by hypothesis 6, change in stress mediated the effects of exercise on depression.

Depression as a mediator of physical well-being. Analyses included in Tables 9 and 10 indicated that group had a significant effect on 9-month change in satisfaction with physical function (ΔR^2= .18, $p<.05$) but did not have a significant effect on either 6-month change in depression (ΔR^2= .07, p=.17) or 9-month change in satisfaction with physical appearance (ΔR^2= .12, p=.09). Thus, in Table 9 the conditions for Path B were violated and in Table 10 the conditions for Path A were violated. Consequently, no further tests were conducted for hypothesis 7.

Perceived pain as a mediator of subjective well-being. In Table 11, paths A, B and C were supported. Once adjusted for baseline values, group had a significant effect on subjective well-being (ΔR^2= .27, $p>.01$) and perceived pain (ΔR^2= .27, p=.01). Adjusted 6-month perceived pain change scores accounted for significant variance in adjusted 9-month subjective well-being index change scores (ΔR^2= .20, $p<.01$). In the final model testing hypothesis 9, the effects of group on 9-month subjective well-being index scores were not significant when the effects of pain were controlled (ΔR^2= .06, p=.12). Therefore, the conditions for full mediation were upheld suggesting that the effects of exercise on subjective well-being were mediated by changes in pain.

Discussion

In the present randomized controlled trial, the effects of a 9-month exercise intervention on pain and physical and psychological well-being were examined. In addition, the overall efficacy of the intervention as a pain management strategy was assessed. The results suggest that exercise is an effective strategy for affecting change in pain perceptions and psychological well-being. In accordance with the Chronic Pain Process Model which conceptualizes the relationships between perceived pain physical well-being and psychological well-being (see Figure 1), it was determined that change in perceived pain was mediated by change in physical well-being, change in stress was mediated by change in perceived pain and change in depression was mediated by change in stress (see Appendix B for summary of results). Taken together, these findings have many important therapeutic and theoretical implications for managing pain in the SCI population.

Effects of Exercise on Outcome Measures

Consistent with the findings in other chronic pain populations (e.g., Buckelew et al., 1998; Ettinger et al., 1997), participation in an aerobic and resistance-training program had a significant effect on pain and psychological and subjective well-being for individuals with SCI. In particular, a group main effect for measures of pain, stress, depression and subjective well-being, reflected improvement in all of these domains for the exercisers (i.e., decreased pain, stress and depression and increased subjective well-being) and decrement in all of these domains for the controls (i.e., increased pain, stress and depression and decreased subjective well-being). These results demonstrate that individuals with SCI can accrue many psychological benefits from participation in resistance and aerobic training. Further, in realizing that participation in exercise can elicit improvement in certain outcomes and failure to exercise can lead to decrement in these same outcomes provides justification for the potential role of exercise not just as a rehabilitation strategy but also as a means for maintaining well-being. Specifically, exercise might be recommended as a method for symptom relief to individuals with SCI who either suffer from chronic pain, depression, stress and/or report low subjective well-being, and to prevent an increase in the severity of their pain symptoms and/or a decline in their current level of psychological and subjective-well being. Such a recommendation might be particularly useful for individuals who have just completed treatment for a psychological illness such as depression and who wish to maintain their improved mental health.

In addition, with the observed group effects being due in part to the controls experiencing more pain, stress and depression and less subjective well-being over the intervention, these results suggest that assigning individuals to a non-exercise control condition might have been detrimental to their well-being. With a lack of exercise facilities available to people with SCI (Martin et al., submitted), being assigned to the control condition might have been particularly distressing for these individuals. In fact, as described in Figure 3, after being assigned to the control condition, one participant became angry and immediately withdrew from the study. According to the Chronic Pain Process Model, eliciting such feelings of distress might have caused the exacerbation of pain symptoms and depression. In future studies, as an alternative to participant randomization, participants could be permitted to self-select their study condition (i.e., participants might select the control condition either for geographical reasons or due to time constraints). Although this alternative research design is not as powerful as a randomized design, it reduces the likelihood of group assignment negatively impacting study participants and alleviates any ethical concerns with random assignment. In summary, it was determined that participation in regular exercise elicited improvement in pain perceptions and psychological and subjective well-being and that not providing the opportunity to exercise regularly might have been detrimental to these outcomes. These findings strengthen the support for advocating for the development of exercise programs for the SCI population, which tends to be underserved (Pentland, Harvey, Smith & Walker, 1999; Tasiemski, Bergstrom, Savic & Gardner, 2000).

Contrary to initial hypotheses, exercise did not affect change in subjective measures of physical well-being across the 9-month intervention. These null findings might be attributable to the use of the Body Satisfaction Scale (Reboussin et al., 2000) as a measure of physical well-being. In hindsight, items on the scale were incongruent with the objectives of the exercise intervention and the nature of physical impairment associated with SCI. For example, the exercise program targeted upper body conditioning and strength, hence, items such as "I am satisfied with the muscle strength in my legs" were incongruent with the training objectives. Further, in members of the SCI population for whom muscle tone is permanently impaired due to nerve damage (Marieb, 1995), items such as "I am satisfied with my muscle tone" were not likely to be affected by an exercise intervention. In future, it is suggested that measures of physical well-being be appropriately tailored to the intervention objectives and the participant sample.

Testing the Relationships Described in the Chronic Pain Process Model

In relating these findings back to the theoretical framework used to guide the current investigation, the Chronic Pain Process Model (Mayer & Gatchel, 1988), these results indicate that exercise affected change in both mediating and outcome variables. As suggested by Baranowski and colleagues (1998), the value in demonstrating change in mediating variables is that it directs focus to understanding the mechanisms of effect in an intervention. In the present randomized control trial, the mechanisms of change were examined in a series of hierarchical linear regression analyses.

The first series of regressions tested the prediction that change in physical well-being would lead to change in perceived pain, as proposed by the Chronic Pain Process Model. This investigation was conducted prospectively such that 0-6 month change in physical well-being (operationalized as satisfaction with physical function) was used to predict 0-9 month change in perceived pain. It was determined that changes in satisfaction with physical function partially mediated the effects of exercise on perceived pain. In finding partial mediation as opposed to complete mediation, as predicted by the Chronic Pain Process Model (Mayer & Gatchel, 1988), there is an indication that other mediators were operating that were not captured by the measure of physical well-being (Baron & Kenny, 1986). Perhaps exercise-related changes in physical dimensions such as strength, endurance and activity level would have been more potent mediators of pain than overall body satisfaction. Thus, in future examinations, it is suggested that as an alternative to the Body Satisfaction Scale, objective measures of physical change (e.g., changes in muscle strength) and/or subjective measures of level of fitness and activity (e.g., Godin Leisure Time Questionnaire [Godin & Shepard, 1985]) be used to assess physical well-being.

The relationship between perceived pain and stress as conceptualized in the Chronic Pain Process Model (i.e., a reduction in pain should lead to a subsequent reduction in stress) was examined in a second series of regression analyses. Once again, these analyses were conducted using a prospective design such that 0-6 month change in perceived pain was used to predict 0-9 month change in stress. Similar to the findings in other chronic pain populations in which pain mediated the effects of exercise on the outcome variable (e.g., knee osteoarthritis; Rejeski et al., 1998), the results from the present study indicated that pain mediated the effects of exercise on stress. Through the identification of the mechanism by which exercise reduces stress, it is clear that exercise interventions striving to reduce stress should target common sources of pain. For example, in the current study, the exercises were designed to train muscle groups in the upper body which are frequently subject to overuse injuries and pain (Dalyan et al., 1999). Perhaps as a result of training these muscle groups, pain was decreased and subsequently contributed to the observed decrease in stress.

In addition to mediating the effects of exercise on stress, change in pain was also predicted to be the mechanism by which exercise affected subjective-well being. In exercise trials, subjective well-being has often been used to evaluate the efficacy of the intervention (Rejeski et al., 1996). Therefore, the aforementioned hypothesis (hypothesis 9), extraneous to the Chronic Pain Process Model, was tested as means of assessing the efficacy of the exercise intervention as a pain management strategy. To examine the hypothesized relationship, the 0-6 month perceived pain change scores were entered into a regression model predicting baseline adjusted, 0-9 month subjective well-being index change scores (see Table 11). From this model it was determined that change in pain mediated the effects of exercise on subjective well-being. Furthermore, this finding suggests that the exercise-related pain reduction contributed to the effectiveness of the intervention as a pain management strategy. In accordance with this finding, it is recommended that exercise programs be implemented in rehabilitation settings for the reduction of pain and in turn, the enhancement of subjective well-being.

Consistent with the Chronic Pain Process Model, it was postulated that change in stress would elicit change in emotional well-being. This hypothesis was tested in a time-lagged design in which 0-6 month change in perceived stress acted as a predictor of 0-9 month change in emotional well-being (operationalized as depression). In agreement with Lazarus' cognitive-motivational-relational theory of emotion (Lazarus, 1991, 1993; Lazarus & Folkman, 1984), change in stress mediated exercise-induced change in depression. From this mediational relationship, it is suggested that as a means of maintaining good mental health, individuals with SCI should incorporate stress-reducing exercises into their daily schedules.

The final mediational relationship described in the Chronic Pain Process Model - between exercise, emotional change and physical well-being - was not upheld. The relationship between the mediator (0-6 month change in depression) and the treatment variable (exercise) was not significant. This null effect was unanticipated because as can be seen in Tables 4 and 8, exercise had a significant effect on depression scores overall

(Table 4) and on the change observed from 0-9 months (Table 8). Thus, it was expected that exercise would also have an effect on depression at 6 months. Rather, it seems that depression scores varied over the exercise intervention. Perhaps this fluctuation was the result of variation in confounding variables, such as the occurrence of comorbidities associated with SCI. In future investigations, an attempt should be made to better control for such variables. For example, in the case of comorbidities, close records should be kept for each individual regarding the occurrence of secondary complications and the duration that they remain bothersome. As a means of controlling for any confounding effects of comorbidities on depression, data from these records should be used as co-variates in all the statistical analyses involving depression.

Collectively, these findings have important therapeutic and theoretical implications. From a therapeutic perspective, through the identification of the particular aspects of an exercise intervention which cause change in pain and psychological and subjective well-being (i.e., mediators), health professionals are provided with an indication of the essential intervention components necessary to maximize intervention effectiveness. A further anticipated benefit of developing interventions that target change in mediating variables is a shorter intervention length needed to affect change (since mediators should be easier to change than outcomes) and a consequent savings in cost (cf., Baranowski et al., 1998).

In addition to advancing knowledge concerning the development of exercise interventions for individuals with SCI, the findings from this intervention study contribute initial empirical support for the conceptual model of the chronic pain process and for understanding the mechanisms by which exercise affects the constructs in the model. It was demonstrated that all of the mediational relationships described in the Chronic Pain Process Model, except for the relationship between emotional change and physical change, were at least partially supported statistically. Consequently, this initial test of the model suggests that the Chronic Pain Process Model might be an accurate conceptualization of the relationships between the physiological and psychological variables affected by chronic pain.

This very preliminary support for the relationships within the Chronic Pain Process Model can be viewed as a gateway for further empirical examinations of the model. For example, it is recommended that relationships among variables be tested in a large sample of individuals with diverse sources of chronic pain. Such a test would allow for the application of large sample statistics (e.g., structural equation modeling) so that all the relationships in the model could be tested concurrently rather than testing individual relationships as in the current study. Further, the inclusion of individuals with various chronic pain complaints would contribute to the generalizability of the model to chronic pain populations other than the SCI population. As well, to be consistent with the model, the relationships between constructs should be tested bi-directionally. In the present investigation, the model was tested in only one direction, to keep the predictions consistent with the cognitive-motivational-relational theory. However, with some evidence suggesting that the relationships might work in the opposite direction (e.g., depression predicts pain; Gasma, 1990), testing the model in the opposite direction is warranted.

The application of the Chronic Pain Process Model for the development of a pain-reduction, exercise intervention, has helped to identify mediators of change and to understand mechanisms by which exercise affects the constructs in the model in individuals with SCI. As a preliminary step that will eventually lead to a test of the model in its entirety, the current study examined each of the mediational relationships separately rather than as a single mediation model as the Chronic Pain Process Model might suggest. Demonstrating that the individual relationships exist is an important contribution in itself. This finding suggests that it might be possible to isolate certain relationships among constructs and to test them experimentally. Experimental examinations as such would help to further validate the Chronic Pain Process Model. To garner further support for the mechanisms described in the current study, it should be determined whether these findings extend to other forms of exercise for individuals with SCI such as body weight supported treadmill training (see Dietz, Wirz, & Jensen, 1997) and functional electrical stimulation (see Guest et al., 1997).

As well as contributing to the understanding of the mechanisms of exercise-induced change in the variables in the Chronic Pain Process Model, the current investigation also provides insight into exercise compliance tendencies in individuals with SCI. As exhibited in Figure 1, similar to the able-bodied population, exercise compliance was a challenge for many of the participants in the current study. Congruent with studies involving able-bodied participants (Dishman, Sallis & Orenstein, 1985), a lack of time was a primary barrier to participation in exercise for individuals with SCI in the current study. In the able–bodied population, time constraints are often a manageable factor (Sallis & Owen, 1999). In contrast, for individuals with SCI, time barriers are often the result of physical impairment and are not easily overcome (Martin, et al., submitted). Thus, when implementing an exercise intervention for individuals with SCI, it might be advisable for health professionals to discuss and implement time-management strategies with each participant.

In addition to time being a major barrier for exercise compliance, other factors unique to the SCI population interfered with exercise attendance. These factors included barriers such as SCI-related illness and transportation difficulties. With many of these SCI-specific factors having never been examined as exercise determinants, there is a definite need for a population-specific, theoretically-driven examination of the determinants of exercise adherence in the SCI population. Such as study would provide much-needed information regarding the key elements for initiating and maintaining exercise among people with SCI.

Limitations

Being one of the first randomized controlled trials to examine the effects of exercise in individuals with SCI, the results of the current study highlight many of the benefits of exercise and provide guidance for the development of exercise interventions for individuals with SCI. However, a word of caution must be extended when interpreting these findings. Given the small sample of adherent participants remaining at the conclusion of the intervention, we caution readers in generalizing these findings to the larger SCI population. A similar study with a larger sample should be conducted to ensure that the findings are reproducible in a larger group. As well, the use of intention to treat analysis (collecting data from all participants including drop-outs at all assessment points) is recommended in order to provide strong evidence of the effectiveness of the exercise intervention.

A second limitation of this randomized control trial was the length of the interval between assessment periods. Evidently, from the results of the current study, the time-lagged design was an effective method for examining the effect of change in the mediator variable for predicting change in the outcome variable. However, the effects might have been stronger had the time between assessment intervals been less than 3-months. With evidence indicating that exercise can induce changes in psychological well-being in less than 3-months (Craft & Landers, 1998; Petruzzello et al., 1991), perhaps changes were occurring that were not captured by the 3-month assessments. Therefore, shortening the interval between assessment periods would allow for more accurate tracking of change and in turn could provided a better indication of the true relationships between variables.

Summary

In conclusion, even with cautious interpretation of the findings from this randomized controlled trial, this research has advanced our understanding of the role of exercise for managing pain and affecting change in psychological and subjective well-being in individuals with SCI. As well, the use of the Chronic Pain Process Model as the foundation for the 9-month exercise intervention has furthered our knowledge of potential mechanisms of exercise-induced change in outcome variables. From a therapeutic perspective, these findings provide evidence as to why individuals with SCI, particularly those with chronic pain, they should adopt a regular exercise regime. The results also provide health professionals with direction for the development of efficacious exercise-centered pain management programs. Additionally, in providing preliminary validation of the relationships within the Chronic Pain Process Model, these findings have important theoretical implications in terms of giving direction for future theory-driven research. With there being such promising evidence of the many psychological benefits of exercise for individuals with SCI, it is hoped that this study is only the first of many exercise interventions used to relieve the symptoms of a disabling comorbidity of SCI –chronic pain.

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Footnote

[1]The pain measure used in the current study did not measure chronic pain but rather the severity of pain in a sample of individuals in which chronic pain is frequently reported (i.e., 18-94% of individuals with SCI report chronic pain; Loubser et al., 1996). Therefore, although chronic pain was not assessed per sae, due to the characteristics of the sample, it was appropriate to use the Chronic Pain Process Model as the framework of the investigation.

Table 1

Reliability Data for All Multi-Item Outcome Measure at Baseline, 3, 6 and 9 Months

	Baseline α	3-month α	6-month α	9-month α
Satisfaction with Physical Functioning Scale	.85	.84	.85	.87
Satisfaction with Physical Appearance	.85	.85	.90	.92
FIM	.94	-	-	-
Perceived Stress	.90	.88	.90	.88
CES-D	.87	.78	.89	.90
Perceived Quality of Life Scale	.84	.88	.90	.76

Note. $\alpha > .70$ is indicative of an acceptable level of reliability. Data for the FIM was collected only at baseline for use as a descriptor of the participant sample.

FIM= Functional Independence Measure

CES-D= Center for Epidemiological Studies Depression Scale

Table 2

Means, Standard Deviations, and Ranges for Continuous Measures of Demographic Variables, Baseline Disability and Impairment

	M		SD		Observed Range	
	E	C	E	C	E	C
Age (yrs)	36.90	43.23	11.73	9.71	19-65	29-63
Age at onset (yrs)	29.19	31.15	13.54	13.85	14-64	18-60
Time since onset (yrs)	7.71	12.08	6.56	7.60	1-23	3-24
FIM	73.25	71.25	22.33	26.02	30-98	30-98
CHART independence	87.68	84.39	17.36	22.45	22-100	22-100
CHART mobility	90.14	89.27	13.11	15.53	53-100	53-100
CHART occupation	45.57	39.63	16.42	15.53	17-71	17-71
CHART social integration	91.15	90.92	14.74	12.30	60-100	60-100

Note. No significant differences observed between groups

Table 3

Frequencies and Percentages of Categorical Measures for Demographic and Impairment Data

	Number		Percent	
	E	C	E	C
Gender				
Female	8	3	72.73	27.27
Male	13	10	56.52	43.48
Education Level§				
Elementary	0	1	0	7.69
Secondary	9	4	42.86	30.77
College	6	4	28.57	30.77
University	2	2	9.52	15.38
Post graduate/professional	0	1	0	7.69
Other	1	0	4.76	0
Not reported	3	1	14.29	7.69
Employment Status				
Employed	9	5	42.86	38.46
Unemployed	5	4	23.81	30.77
Student	2	1	9.52	7.69
Disability	5	2	23.81	15.38
Retired	0	1	0	7.69

(continued)

	Number		Percent	
	E	C	E	C
Etiology of SCI				
Motor vehicle accident	8	4	38.10	30.77
Sport	8	3	38.10	23.08
Violence	1	1	4.76	7.69
Fall	4	4	19.05	30.77
Other	0	1	0	7.69
Completeness of Injury				
Incomplete	15	8	71.43	61.54
Complete	6	5	28.57	38.46
Level of Injury				
Cervical	9	7	42.86	53.85
Thoracic	11	4	52.38	30.77
Lumbar	0	2	0	15.38
Sacral	1	0	4.76	0
Paraplegia vs. Tetraplegia				
Paraplegia	11	10	52.38	76.92
Tetraplegia	7	6	33.33	46.15

(continued)

	Number		Percent	
	E	C	E	C
ASIA score				
A	6	7	28.57	53.85
B	3	0	14.29	0.00
C	6	3	28.57	23.08
D	6	3	28.57	23.08

Note. No significant differences observed between groups

§ Highest level of education enrolled in for a minimum of 1 year

ASIA= American Spinal Injury Association

Table 4

Baseline and Adjusted Percent Change (0-3, 3-6 and 6-9 Months) and Group Descriptive Statistics for Intervention Outcome Measures

	Baseline		0-3 months percent change		3-6 months percent change		6-9 months percent change		Group percent change	
Variable	M	SD	M	SD	M	SD	M	SD	M	SD
SPF										
Exercise	26.24	8.88	7.72	.466	4.67	5.01	2.58	4.44	4.99	1.26
Control	22.54	8.06	-12.55	4.91	7.14	5.28	10.12	4.67	1.57	1.32
SPA										
Exercise	15.43	6.49	11.09	4.23	6.80	3.84	-.94	3.59	5.65	1.71
Control	14.31	7.22	-2.20	4.54	3.23	4.04	5.33	3.78	2.12	1.80
Pain										
Exercise	5.10	1.79	-.52	.62	-.32	.43	-.17	.49	-.34**	.12
Control	5.85	2.41	1.68	.65	-.15	.46	-.51	.51	.34	.13

(continued)

Variable	Baseline		0-3 months percent change		3-6 months percent change		6-9 months percent change		Group percent change	
	M	SD	M	SD	M	SD	M	SD	M	SD
Stress										
Exercise	37.71	10.48	-5.00	2.81	-.37	2.46	-3.59	1.99	-2.99**	.92
Control	42.77	10.81	5.15	2.96	.41	2.58	-2.48	2.09	1.03	.96
Depression										
Exercise	11.71	7.77	-2.89	4.62	2.55	2.58	-3.34	2.91	-1.23*	1.44
Control	12.46	8.32	11.18	4.85	-1.63	2.71	1.67	3.06	3.74	1.52
Subjective Well-Being										
Exercise	-.02	1.62	11.01	10.56	1.80	7.47	4.79	7.70	5.87**	3.09
Control	.03	2.15	-18.40	11.07	-11.14	7.83	2.22	8.07	-9.10	3.24

Note. *between group comparison $p<.05$, **between group comparison $p<.01$. All participants' data included for baseline mean calculation (N =34). Paired t-test analyses on baseline means indicated that there were no between group differences at baseline. Three, 6 and 9 month follow-up scores are reported for participants who completed all 3 follow-up assessments (exercise n=11, control n=10). SPF= Satisfaction with physical functioning SPA= Satisfaction with physical appearance

Table 5

Linear Models Testing 0-6 Month Percent Change in Satisfaction with Physical Functioning as a Mediator of 0-9 Month Percent Change in Perceived Pain

Predictor Variables	Outcome Variables	ΔR^2	Adjusted R^2 of model	Beta	t for parameter
Path A	0-9month pain				
Baseline pain		.08		-.41	-2.56*
Group		.43**	.46**	.67	4.18**
Path B	0-6 month SPF				
Baseline SPF		.17*		-.53	-2.92*
Group		.19*	.41**	-.45	-2.50*
Path C	0-9 month pain				
Baseline pain		.06		-.44	-1.89
Baseline SPF		.00		-.31	-1.19
0-6 month SPF		.19*	.12	-.54	-2.11*
Path D	0-9 month pain				
Baseline pain		.06		-.42	-2.28*
Baseline SPF		.00		.11	.47
6-month SPF		.19*		-.21	-.91
Group		.31**	.44**	.67	3.39**

Note. *$p<0.05$, **$p<0.01$

SPF= Satisfaction with physical functioning

Table 6

Linear Models Testing 0-6 Month Percent Change in Satisfaction with Physical Appearance as a Mediator of 0-9 Month Percent Change in Perceived Pain

Predictor Variables	Outcome Variables	ΔR^2	Adjusted R^2 of model	Beta	t for parameter
Path A	0-9 month pain				
Baseline pain		.08		-.41	-2.56*
Group		.43**	.46**	.67	4.18**
Path B	0-6 month SPA				
Baseline SPA		.17*		-.53	-2.92*
Group		.19*	.30**	-.45	-2.50*
Path C	0-9 month pain				
Baseline pain		.06		-.28	-1.33
Baseline SPA		<.01		-.14	-.61
6-month SPA		.16	.09	-.44	-1.93

Note. *$p<0.05$, **$p<0.01$

SPA= Satisfaction with physical appearance

Table 7

Linear Models Testing 0-6 Month Percent Change in Perceived Pain as a Mediator of 0-9 Month Percent Change in Stress

Predictor Variables	Outcome Variables	ΔR^2	Adjusted R^2 of model	Beta	t for parameter
Path A	0-9 month stress				
Baseline stress		.32**		-.67	-4.25**
Group		.21**	.49**	.47	3.01*
Path B	0-6 month pain				
Baseline pain		.15		-.52	-3.03*
Group		.27**	.36**	.53	3.11*
Path C	0-9 month stress				
Baseline stress		.32**		-.83	-4.52**
Baseline pain		.13*		.59	2.99*
0-6 month pain		.11**	.49**	.36	2.12*
Path D	0-9 month stress				
Baseline stress		.32**		-.85	-4.99**
Baseline pain		.13*		.43	2.13*
0-6 month pain		.11*		.15	.76
Group		.08	.56**	.36	1.98

Note. *p<0.05, **p<0.01

Table 8

Linear Models Testing 0-6 Month Percent Change in Stress as a Mediator of 0-9 Month Percent Change in Depression

Predictor Variables	Outcome Variables	ΔR^2	Adjusted R^2 of model	Beta	t for parameter
Path A	0-9 month depression				
Baseline depression		.153		-.44	-2.43*
Group		.19*	.28*	.44	2.41*
Path B	0-6 month stress				
Baseline stress		.24**		-.62	-3.76**
Group		.23**	.42**	.50	3.03*
Path C	0-9 month depression				
Baseline depression		.15		-.63	-3.28**
Baseline stress		.06		.72	3.45**
0-6 month stress		.43**	.58**	.75	4.52**
Path D	0-9 month depression				
Baseline depression		.15		-.63	-3.21*
Baseline stress		.06		.68	2.90*
0-6 month stress		.43**		.70	3.50**
Group		<.01	.56**	.08	.46

Note. *p<0.05, **p<0.01

Table 9

Linear Models Testing 0-6 Month Percent Change in Depression as a Mediator of 0-9 Month Percent Change in Satisfaction with Physical Functioning

Predictor Variables	Outcome Variables	ΔR^2	Adjusted R^2 of model	Beta	t for parameter
Path A	0-9 month SPF				
Baseline SPF		.09		-.47	-2.28*
Group		.19*	.19*	-.45	-2.18*
Path B	0-6 month depression				
Baseline depression		.23*		-.50	-2.73*
Group		.07	.22*	.26	1.41

Note. *$p<0.05$, **$p<0.01$

SPF= Satisfaction with physical functioning

Table 10

Linear Models Testing 0-6 Month Percent Change in Depression as a Mediator of 0-9 Month Percent Change in Satisfaction with Physical Appearance

Predictor Variables	Outcome Variables	ΔR^2	Adjusted R^2 of model	Beta	t for parameter
Path A	0-9 month SPA				
Baseline SPA		.13		-.43	-2.19*
Group		.12	.18	-.36	-1.81

Note. *$p<0.05$, **$p<0.01$

SPA=Satisfaction with physical appearance

Table 11

Linear Models Testing 0-6 Month Percent Change in Perceived Pain as a Mediator of 0-9 Month Percent Change in Subjective Well-Being

Predictor Variables	Outcome Variables	ΔR^2	Adjusted R^2 of model	Beta	t for parameter
Path A	0-9 month SWB				
Baseline SWB		.25*		-.48	-3.09*
Group		.27**	.47**	-.52	-3.35**
Path B	0-6 month pain				
Baseline pain		.15		-.52	-3.03*
Group		.27**	.36**	.53	3.11*
Path C	0-9 month SWB				
Baseline SWB		.25*		-.48	-3.02*
Baseline pain		.12		-.54	-3.18*
0-6 month pain		.20**	.50**	-.50	-2.93*
Path D	0-9 month SWB				
Baseline SWB		.25*		-.49	-3.22*
Baseline pain		.12		-.39	-2.12**
0-6 month pain		.20**		-.31	-1.58
Group		.06	.54**	-.30	-1.64

Note. *$p<0.05$, **$p<0.01$

SWB= Subjective well-being

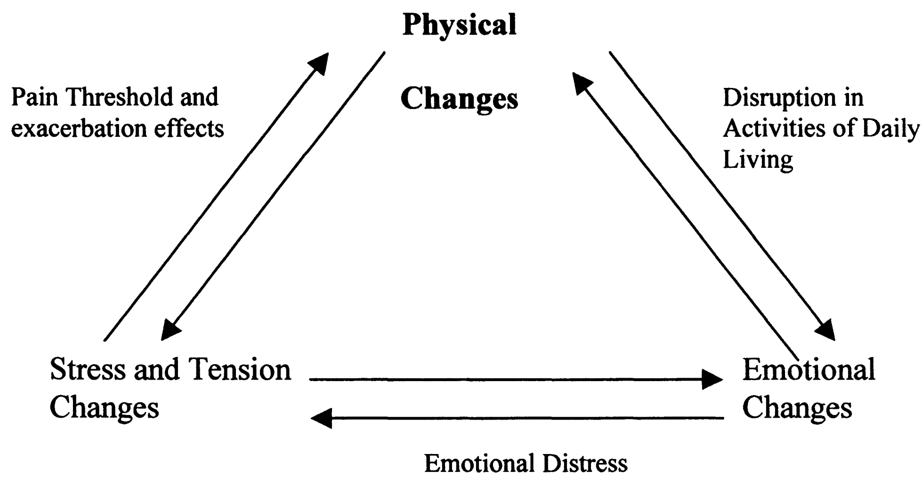


Figure 1. Mayer and Gatchel's (1988) Conceptual Model of the Pain Process

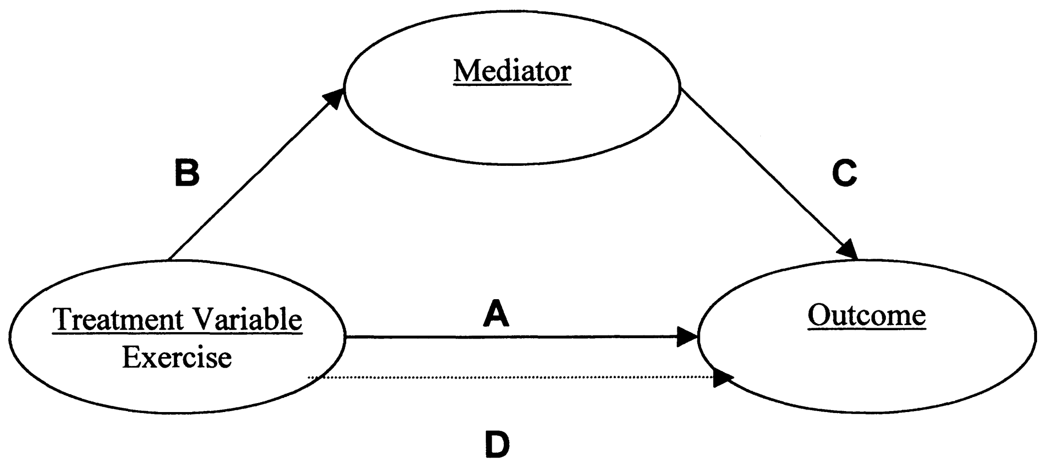


Figure 2. Conceptual model used for mediational analyses.

The dashed line indicates a non-significant relationship after controlling for path C.

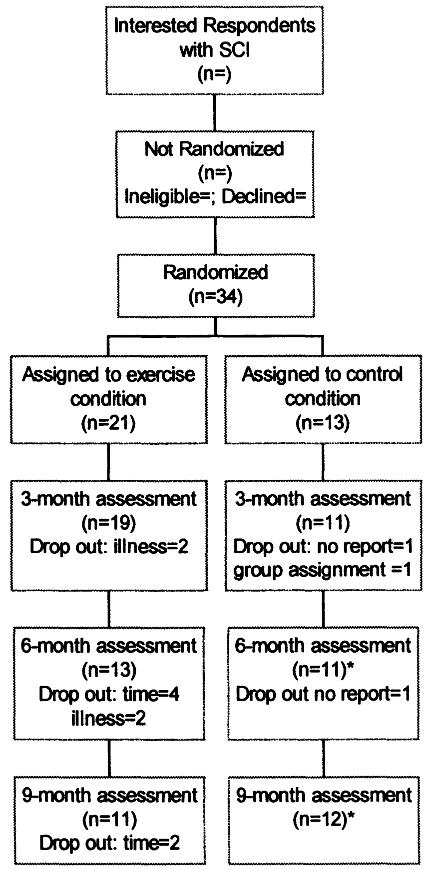


Figure 3. Progress of participants through the 9-month trial. The reasons for ineligibility included meeting 1 or more of the exclusion criteria. Specific reasons for drop-out related to time included return to fulltime work or school, travel and illness.

* The data for the 2 participants who failed to report, 1 at 3-months and 1 at 6-months, was excluded from all repeated measure analyses.

Appendix A

Glossary of Terms

Glossary of Terms

The following terms are defined according to the International Classification of Functioning, Disability and Health (ICIDH-2; World Health Organization, 2001)

Impairment. A loss or abnormality of a body part (i.e., structure) or body function (i.e., physiological function). Physiological functions include mental function. Abnormality is used strictly to refer to a significant variation from established statistical norms (i.e., as a deviation from a population mean within measured standard norms).

Disability. An umbrella term for impairments, activity limitation and participation restrictions (e.g., difficulty in performing activities of daily living). It denotes the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors).

Handicap*. A disadvantage for a given individual that limits or prevents the fulfillment of a role that is normal (depending on age, sex and social and cultural factors) for that individual (World Health Organization, 1980).

*In the most recent version of the ICIDH-2 states that the term handicap has been abandoned and is captured under the umbrella term "disability". However, because most of the existing research has not adopted this change in terminology, it was necessary to use the term handicap throughout the current document.

Appendix B

Summary of Results

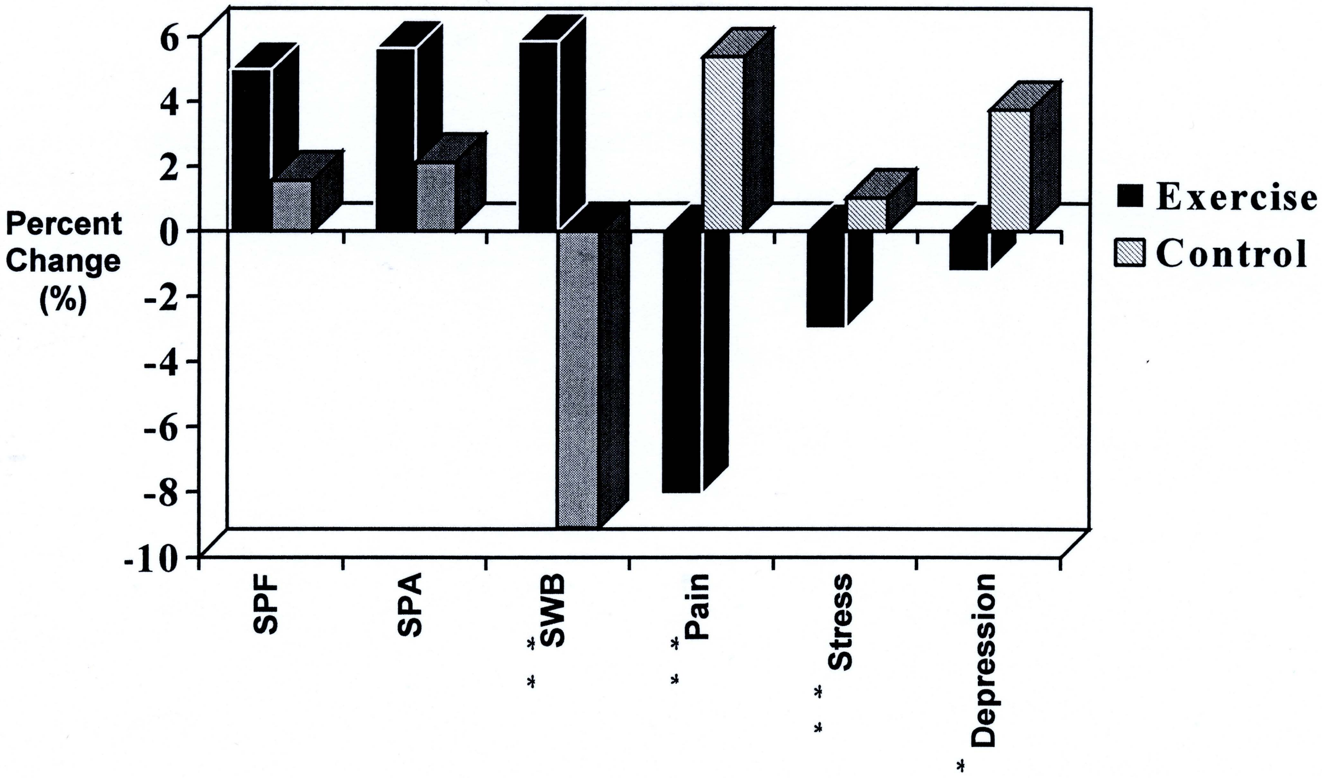
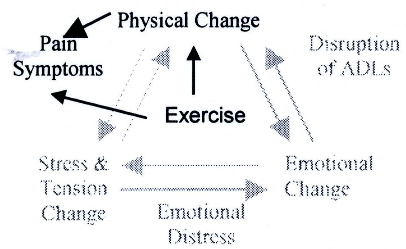
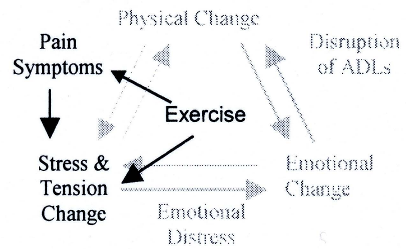


Figure 4. Baseline adjusted group mean percent change scores for all outcome variables over the 9-month intervention. SPF= Satisfaction with physical function, SPA= Satisfaction with physical appearance, SWB= Subjective well-being

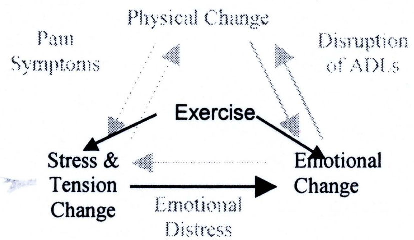
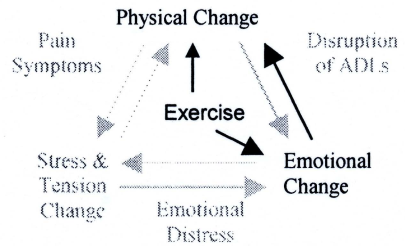
*p<.05
**p<.01

Table 12

<u>Summary of results from tests of the mediational relationships described in the chronic pain process model</u>

Hypothesis tested	Corresponding component of CCPM	Result
H_4: the effects of exercise on perceived pain would be mediated by exercise-induced change in physical well- being (satisfaction with physical function and appearance)		Partial mediation - Satisfaction with physical function as mediator No mediation - Satisfaction with physical appearance as mediator
H_5: the effects of exercise on stress would be mediated by exercise induced change in perceived pain		Full mediation

(continued)

Hypothesis tested	Corresponding component of CCPM	Result
H_6: the effects of exercise on depression would be mediated by exercise-induced change in stress.		Full mediation
H_7: the effects of exercise on physical well-being (satisfaction with physical function and appearance) would be mediated by exercise-induced change in depression		No mediation

Note. CCPM= Chronic Pain Process Model. Full mediation occurred when the conditions for Paths A, B and C were met and the effects of exercise on the outcome variable (Path D) was no longer significant after controlling for the mediating variable (refer to Figure 2 for diagram of Paths A, B, C and D). Partial mediation occurred when exercise had a significant effect on the outcome after controlling for the mediating variable (Path D) but the effect was smaller than when the mediator was left unaccounted (Path A).

Appendix C

Participant Description Measures

- Functional Independence Measure (FIM)
- Craig Handicap Assessment and Reporting Technique (CHART)

Intervention Outcome Measures:

- Bodily Pain Subscale
- Body Satisfaction Questionnaire
- Perceived Stress Scale
- Centre for Epidemiological Studies Depression Scale
- Cantril's Ladder
- Perceived Quality of Life Scale

FUNCTIONAL INDEPENDENCE MEASURE

(Hamilton et al., 1987)

Levels

NO HELPER

7	Complete Independence- Performed safely and without an assistive device.
6	Modified Independence- Require special assistive device or takes more than a reasonable amount of time.

HELPER

5	Supervision or Setup- Require supervision or setup to perform function.
4	Minimal Contact Assistance- Perform 75% or more of function.
3	Moderate Assistance- Perform 50% to 74% of function.
2	Maximal Assistance- Perform 25% to 49% of function.
1	Total Assistance- Perform less than 25% of function.

Self Care	**Level**
a. Eating	_____
b. Grooming	_____
c. Bathing	_____
d. Dressing- upper body	_____
e. Dressing- lower body	_____
f. Toileting	_____

Sphincter Control	**Level**
g. Bladder Management	_____
h. Bowel Management	_____

Mobility	**Level**
Transfer:	
i. Bed, Chair, Wheelchair	_____
j. Toilet	_____
k. Tub, Shower	_____

Locomotion	**Level**
l. Walk/Wheelchair	w_____ c_____
m. Stairs	_____

CRAIG HANDICAP ASSESSMENT AND REPORTING TECHNIQUE

(CHART; Whiteneck et al., 1992b**)**

1. How many hours in a typical 24 hour day do you have someone with you to provide assistance?

	Hours Unpaid	Hours Paid
Weekday		
Weekend		

2. Not including any regular care as reported above, how many hours in a typical **month** do you occasionally have assistance with such things as grocery shopping, laundry, housekeeping, or infrequent medical needs like catheter changes?

	Hours
Month	

3. Who takes responsibility for instructing and directing your attendants and/or caregivers?

____

ARE YOU UP AND ABOUT REGULARLY?

4. On a typical **day**, how many hours are you out of bed? _____hours
5. In a typical **week**, how many days do you get out of your house to go somewhere? _____days
6. In the last **year**, how many nights have you spent away from your home (excluding hospitalization)? 0, 1-2, 3-4, 5+
7. Can you enter and exit your home without any assistance from someone? yes/no
8. In your home, do you have independent access to your sleeping area, kitchen, bathroom, telephone, television, or radio? yes/no

IS YOUR TRANSPORTATION ADEQUATE

9. What is your primary method of transportation outside the home?

___private vehicle ___public transport ___wheelchair(if yes, skip to #14)

10. Can you use your transportation independently? yes/no
11. Does your transportation allow you to get to all the places you would like to go? yes/no
12. Does your transportation let you get out whenever you want? yes/no
13. Can you use your transportation with little or no advance notice? yes/no (if no, skip to #18)
14. Can you get to the places you would like to go in your wheelchair? yes/no
15. Does **time** limit using your wheelchair to get around? yes/no
16. Does **weather** limit using your wheelchair to get around? yes/no
17. Do you have alternate transportation for longer trips? yes/no

HOW DO YOU SPEND YOUR TIME?

18. How many hours per **week** do you spend working in a job for which you get paid? ___hours ____________________occupation
19. How many hours per **week** do you spend in school working toward a degree or in an accredited technical training program? ___hours in class
20. How many hours per **week** do you spend in active homemaking including parenting, housekeeping and food preparation? ___hours
21. How many hours per **week** do you spend in home maintenance activities such

as yard work, house repairs or home improvement? ___hours

22. How many hours per **week** do you spend in on-going volunteer work for an organization? ___hours
23. How many hour per **week** do you spend in recreational activities such as sports, exercise, playing cards or going to movies? ___hours
    (Please do not include time spent watching TV or listening to radio)
24. How many hours per **week** do you spend in other self-improvement activities such as hobbies or leisure reading? ___hours
    (Please do not include time spent watching TV or listening to radio)

WITH WHOM DO YOU SPEND YOUR TIME?

25. Do you live:

Situation	Fill in box	How many?
Alone	just me	0
Spouse or significant other		1
Children		
Other relatives		
Roommate		
Attendant		

26. If you do not live with a spouse or significant other, are you involved in a romantic relationship? yes/no
27. How many relatives (not in your household) do you visit, phone or write to at least once a month? ___
28. How many business or organizational associates do you visit, phone or write at lease once a month? ___
29. How many friends (non-relatives contacted outside business or organizational setting) do you visit, phone or write to at least once a month? ___
30. With how many strangers have you initiated a conversation in the last month (for example, to ask for information or to place an order)?
    ___none ___1-2 ___3-5 ___6+

BODILY PAIN SUBSCALE

(Ware & Sherbourne, 1992)

During the past 4 weeks, how much bodily pain have you had?

☐	☐	☐	☐	☐	☐
None	Very mild	Mild	Moderate (medium)	Severe	Very severe

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

BODY SATISFACTION QUESTIONNAIRE

(Reboussin et al., 2000)

In the past 4 weeks, how satisfied have you been with …

		Very Dissatisfied	Somewhat Dissatisfied	A little Dissatisfied	Neither	A little Satisfied	Somewhat Satisfied	Very Satisfied
1	your overall level of physical activity?							
2	the muscle strength in your legs?							
3	your level of endurance or stamina?							
4	your muscle tone?							
5	Your overall level of energy?							
6	your physical ability to do what you want or need to do?							
7	your weight?							
8	your shape?							
9	your overall physical appearance?							
10	the muscle strength in your arms?							

THE PERCEIVED STRESS SCALE

(Cohen et al., 1983)

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
1.	Been upset because of something that happened unexpectedly?						
2.	Felt that you were unable to control the important things in your life?						
3.	Felt nervous and "stressed"?						
4.	Dealt unsuccessfully with irritating life hassles?						
5.	Felt that you were effectively coping with important changes that were occurring in your life?						
6.	Felt confident about your ability to handle your personal problems?						
7.	Felt that things were going your way?						
8.	Found that you could not cop with all the things that you had to do?						

In the past 4 weeks, how satisfied have you been with ...

		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
9.	Been able to control irritations in your life?						
10.	Felt that you were on top of things?						
11.	Been angered because of things that happened outside your control?						
12.	Found yourself thinking about things that you have to accomplish?						
13.	Been able to control the way you spend your time?						
14.	Felt difficulties were piling up so high that you could not overcome them?						

CENTRE FOR EPIDEMIOLOGICAL STUDIES DEPRESSION SCALE

(CES-D; Radloff, 1977)

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 filling in the appropriate number.

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

1. I was bothered by things that don't usually 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 depressed. _____
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". _____

PERCEIVED QUALITY OF LIFE SCALE

(Patrick et al., 1988)

In the past 4 weeks, how satisfied have you been with ...

		Very Dissatisfied	Somewhat Dissatisfied	A little Dissatisfied	Neither	A little Satisfied	Somewhat Satisfied	Very Satisfied
1	how well you think and remember?							
2	the amount of walking or wheeling you do?							
3	how often you get outside of the house, going into town, using public transportation or driving?							
4	how often you see or talk to your family and friends?							
5	the help you get from your family and friends?							
6	your contribution to your community, neighbourhood, religious or other group?							
7	your retirement, or school, or current job?							
8	the kind and amount of recreation or leisure you have?							

In the past 4 weeks, how satisfied have you been with …

		Very Dissatisfied	Somewhat Dissatisfied	A little Dissatisfied	Neither	A little Satisfied	Somewhat Satisfied	Very Satisfied
9	your level of sexual activity or lack of sexual activity?							
10	how respected you are by others?							
11	the meaning and purpose of your life?							
12	the amount and kind of sleep you get?							
13	how happy you are?							

CANTRIL'S LADDER

(Cantril, 1965)

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 □)