ADIPOSITY AND CORONARY HEART DISEASE RISK FACTORS IN INDIVIDUALS WITH SPINAL CORD INJURY: RELATIONSHIPS WITH ACTIVITIES OF DAILY LIVING, SECONDARY COMPLICATIONS, AND SUBJECTIVE WELL-BEING

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ABSTRACT

The purpose of this thesis was to examine coronary heart disease (CHD) risk factors and secondary complications in individuals with spinal cord injury (SCI). In particular, this thesis was organized around the central theme of adiposity, which is a prevalent complication following SCI.

Study 1 focused on understanding the relationships between activities of daily living (ADL) and CHD risk factors including central adiposity, lipoproteins, and triglycerides. Using generalized linear models, while controlling for pertinent covariates such as sex, age, and leisure time physical activity (LTPA), it was found that Mobility ADL (wheeling and transferring) were negatively associated with total and LDL-cholesterol.

Study 2 examined whether individuals who considered themselves to be overweight subsequently had less favourable subjective well-being, and were more likely to report specific secondary complications than individuals who did not consider themselves to be overweight. Logistic regression analysis and partial correlations controlling for pertinent covariates such as sex, age, and injury severity, revealed that individuals who considered themselves to be overweight reported greater pain, depression, overuse injuries, and fatigue, and less satisfaction with life than individuals who did not consider themselves to be overweight.

In summary, the findings suggest that a) participation in specific types of ADL (i.e. Mobility ADL) are associated with a lower CHD risk and should be further explored and that b) elevated perceived adiposity is associated with specific secondary complications and lower subjective well-being. Overall thesis findings support the overwhelming

evidence of the benefits of daily physical activity and maintaining a healthy bodyweight in the SCI population.

Key Words: spinal cord injury, paraplegia, tetraplegia, activities of daily living, coronary heart disease risk factors, adiposity, secondary complications, subjective well-being

CO-AUTHORSHIP

This thesis presents the work of Samuel Hetz in collaboration with his advisor, Dr. Amy Latimer and the SHAPE-SCI Research Group.

Manuscript 1: *Increased ADL participation is associated with lower cholesterol levels in individuals with SCI* has been accepted for publication in the *Archives of Physical Medicine and Rehabilitation*. Samuel Hetz developed the concept for the study and was primarily responsible for the data analysis, interpreting the study results, and drafting the original manuscript. The data used in this study was obtained from the SHAPE-SCI, which is funded by a Canadian Institutes of Health Research (CIHR) New Investigator Award, awarded to Dr. Kathleen Martin Ginis. His supervisor, and co-authors, Dr. Kathleen Martin Ginis, and Dr. Andrea Buchholz were instrumental in the planning of the study and preparation of the manuscript.

Manuscript 2: *Secondary complications and subjective wellbeing in individuals with chronic spinal cord injury: Relationships with self-reported adiposity* has been prepared for submission to *International Journal of Rehabilitation Research*. Samuel Hetz developed the concept for the study and was primarily responsible for the data analysis, interpreting the study results, and drafting the original manuscript. The data used in this study were obtained from the SHAPE-SCI, which is funded by a CIHR New Investigator Award, awarded to Dr. Kathleen Martin Ginis. His supervisor, and co-authors, Dr. Kathleen Martin Ginis, and Dr. Kelly Arbour were actively involved in the planning of the study and preparation of the manuscript.

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LIST OF TERMS AND ABBREVIATIONS

ADL – Activities of Daily Living

BMI – Body Mass Index (kg/m^2)

CHD – Coronary Heart Disease

CIHR – Canadian Institutes of Health Research

CVD – Cardiovascular Disease

DVT – Deep Vein Thrombosis

GLM – Generalized Linear Models

HDL – High-density Lipoprotein (mmol/L)

IASP – International Association for the Study of Pain

LDL – Low-density Lipoproteins (mmol/L)

LTPA – Leisure Time Physical Activity

NEAT – Non-exercise Activity Thermogenesis

NHANES III – Third National Health and Nutrition Examination Survey

PARA-SCI – Physical Activity Recall Assessment for People with Spinal Cord Injury

PHQ-9 – Patient Health Questionnaire

SWB – Subjective Well-being

SCI – Spinal Cord Injury

SF-36 – Short Form 36 Health Questionnaire

SHAPE- SCI – Study of Health and Activity in People with Spinal Cord Injury

SPSS – Statistical Package for the Social Sciences

SWLS – Satisfaction with Life Scale

UTI – Urinary Track Infection

YPI – Years Post Injury

CHAPTER 1. GENERAL INTRODUCTION

1.1 Introduction

It only takes an instant to acquire a spinal cord injury (SCI), yet the devastating effects last a life time.[1] At least some degree of paralysis almost always occurs following a SCI. In addition to paralysis, individuals with SCI also often suffer from a myriad of other SCI related illnesses and comorbidities.[2]

Overwhelming evidence suggests that individuals with SCI often have a higher level of adiposity[i] than able bodied counterparts.[3] This increased level of adiposity combined with lower levels of physical activity place individuals with SCI at an increased risk for comorbidities such as coronary heart disease (CHD) and diabetes. Possible ways to mitigate this elevated risk are greatly needed. Leisure time physical activity (LTPA) has been identified a strategy to lower adiposity and CHD risk.[4,5] However, the role of other daily activities, particularly activities of daily living (ADL), in decreasing adiposity and CHD risk is unknown.

Increased adiposity also may be related to secondary complications and subjective well-being (SWB) in the SCI population. The relationships between adiposity, secondary complications, and SWB have been identified in the able bodied population, but have yet to be examined in the SCI population.

1.2 Primary Thesis Objectives and Hypotheses

1) To determine the relationships between CHD risk factors and ADL participation. It was hypothesised that certain ADL such which required large and sustained

[i] *Adiposity is synonymous with body fatness. Elevated levels of adiposity can lead to obesity.*

muscle activity such as mobility and domestic activities would be negatively associated with CHD risk factors.

2) To determine the relationships between perceived adiposity, secondary complications, and SWB (i.e. satisfaction with life and depressive symptoms) in the SCI population. It was hypothesized that individuals who perceived themselves to be overweight would report an increased prevalence of certain secondary complications and would report less favourable SWB than individuals who did not consider themselves to be overweight.

1.3 Thesis Organization

This thesis conforms to the regulations outlined in the Queen's School of Graduate Studies and Research "General Forms of Theses." Chapter two provides an in-depth review of literature focusing on thesis related topics. The third chapter provides a detailed description of the studies hypotheses, designs, and methods. The fourth chapter contains the first manuscript which explores the relationships between ADL participation and CHD risk factors. This manuscript has been accepted for publication in the *Archives of Physical Medicine and Rehabilitation*. Chapter five contains the second manuscript which examines the relationships between perceived body weight status, secondary complications associated with SCI and SWB. This manuscript has been prepared for submission in the *International Journal of Rehabilitation Research*. Finally, Chapter six contains a general discussion.

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CHAPTER 2. REVIEW OF LITURATURE

2.1 Overview of Spinal Cord Injury

The spinal cord is the primary route in which motor and sensory information is transmitted between the brain and body. This half-meter long, bi-directional collection of nervous tissue originates at the base of the brain and runs continuously to the coccyx or 'tail bone'. The spinal cord is encased in a series of bones called the vertebrae, which protect the spinal cord, provides stability, and allows for flexibility. The spinal cord consists of thirty-one segments, which control various autonomic/involuntary (i.e. breathing, vasoconstriction, heart rate) and somatic/voluntary (i.e. muscle contraction) systems in addition to receiving sensory information from the periphery. The spinal cord is divided into four sections including the cervical, thoracic, lumbar, and sacral sections. The cervical section consists of the most superior 8 segments, followed by the 12 thoracic segments, and ending with the 5 lumbar and 4 most inferior sacral sections.[1,2]

When the spinal cord is damaged a spinal cord injury (SCI) occurs. The injury prevents neurons from transmitting information effectively between the brain and effectors (e.g. muscles, glands, organs) and a loss in sensory and/or motor function occurs. The degree to which function is lost is dependant on both the level and completeness of the injury. Level of injury refers to the location of the lesion on the spinal cord. For example, an injury sustained in the cervical spinal cord may affect autonomic processes as well as motor function in all four limbs resulting in a condition known as tetraplegia. Conversely, an injury sustained in the thoracic or lumbar regions of the spinal cord would result in an impairment or total loss of function in only the lower portion of the body which is known as paraplegia. SCI may be complete meaning that there is a total loss in sensory and motor function below the level of injury, or incomplete indicating that some sensory and/or motor function is spared.[3] Therefore, an individual may have tetraplegia, but due to an incomplete injury this person may still be able to move their lower limbs and/or ambulate. The American Spinal Injury Association (ASIA)[3] categorizes each SCI in a 5-point categorization scale. Each letter represents a specific level of motor function, sensory function, and completeness. The ASIA impairment scale is included below.

Table 1. ASIA Impairment Scale

Grade	Characteristics
A	*Complete:* No sensory or motor function is preserved in sacral segments S4-S5.
B	*Incomplete:* Sensory, but not motor, function is preserved below the neurologic level and extends through sacral segments S4-S5.
C	*Incomplete:* Motor function is preserved below the neurologic level, and most key muscles below the neurologic level have muscle grade less than 3 out of 5.
D	*Incomplete:* Motor function is preserved below the neurologic level, and most key muscles below the neurologic level have muscle grade greater than or equal to 3 out of 5.
E	*Normal:* Sensory and motor functions are normal.

2.2 Epidemiological Considerations

Age adjusted incidence rates of SCI in Canada are approximately 41 per million people per year. The highest prevalence rates of SCI are among individuals between 20-40 years of age.[4] SCI among children and young teenagers is very uncommon, however there appears to be an increasing number of elderly individuals incurring SCI primarily due to falls.[4] The most common causes of SCI in Canada are motor vehicle accidents, accounting for approximately 35% of injuries and falls accounting for 31% of injuries. Less common causes in order of decreasing incidence include accidents involving vehicles other than automobiles (bikes and snowmobiles), sports-related injuries, and violence related injuries such as gun shot wounds.[4] On average, 50% of SCI result in tetraplegia, while 50% result in paraplegia.[5,6] Finally, SCI is approximately three to four times more prevalent in men than in women.[7] This discrepancy between sexes may be due to more risky behaviour attributed to young adult males.

2.3 Comorbidities and Metabolic Complications of Spinal Cord Injury

In addition to the loss of sensory and motor function, individuals with SCI are at an increased risk for other comorbidities and secondary complications.[8] Some of the most prevalent secondary complications are due to elevated levels of adiposity,[9] decreased muscle mass,[10] and metabolic disturbances.[11] However, it is important to acknowledge that these manifestations do not occur in isolation, but are interrelated and often accompany one another.

2.3.1 Elevated Adiposity and Spinal Cord Injury

In the able bodied population, obesity has reached epidemic proportion worldwide. Currently, more than 1 billion adults (1/7 of the total human population) are considered overweight (Body Mass Index (BMI) ≥ 25kg/m^2) and at least 300 million of these are considered clinically obese (BMI ≥ 30kg/m^2).[12] In Canada, approximately 6.8 million adults aged 20 to 64 are overweight, and an additional 4.5 million are obese. These numbers are staggering, suggesting that about 60% of the adult population is either overweight or obese.[13] Unfortunately, because these data were reported almost five years ago, the statistics almost surely underestimate the current extent of the epidemic.

In the SCI population the levels of adiposity and obesity are higher than in the able bodied population. Approximately 66% of individuals with SCI are considered overweight or obese.[14] Although this level of adiposity is only slightly higher than that of the able bodied population,[15] it has been suggested that current classifications of ‘overweight’ and ‘obese’ for able bodied individuals do not accurately characterize those with SCI.[16] This misclassification is due to limitations of existing adiposity measures in the SCI population.

2.3.2 Adiposity Measurement Considerations

Adiposity can be measured in a multitude of ways including, dual energy x-ray absorptiometry, magnetic resonance imaging, skin folds, and hydrodensiometry/underwater weighing. However, adiposity and the current classifications of 'overweight' and 'obese' are often based on body mass index (BMI) or waist circumference. Both BMI and waist circumference are of clinical significance due to the simplicity and ease which the measurements can be obtained.

BMI is determined by dividing an individual's total body weight (kg) by their height (m) squared. BMI can be determined subjectively by using self-reported height and weight and objectively by using measured height and weight. An individual with a BMI of less than 18 kg/m^2 is considered underweight, 18 to 24.9 kg/m^2 is normal weight, 25 to 29.9 kg/m^2 is overweight and a person with a BMI of greater than 30 kg/m^2 is considered obese.[12] One of the major caveats is that BMI does not discriminate between fat- and fat-free mass. As SCI is accompanied by a decrease in muscle mass and an increase in fat-mass, an individual with a SCI may have a normal BMI, but have the level of body fat usually seen in an obese individual.[17] Recent findings suggest waist circumference is a better predictor of cardiovascular disease (CVD) in the SCI population, accounting for more of the variance in CVD risk factors than BMI.[19]

Waist circumference is measured either at the top of the iliac crest, at the point of the lowest rib, or the mid point between the lowest rib and iliac crest. The measurement at the iliac crest, is most commonly used and is in accordance with the Third National Health and Nutrition Examination Survey (NHANES III)[18] as well as the Study of Health and Activity in People with Spinal Cord Injury (SHAPE-SCI).[19] However, this anatomical landmark may be difficult to located in more obese adults, and therefore the measurement at the lowest rib also is widely used.[16] A recent study determined that waist circumference values measured at four sites (immediately below the lowest rib, at the narrowest waist, midpoint between the lowest rib, and the iliac crest and immediately above the iliac crest) had equally reproducibility and were almost equally associated with total body fat and trunk fat in each sex.[20]

Adiposity was evaluated in three ways within this thesis. In Study 1, adiposity was assessed using objectively measured waist circumference. In Study 2, adiposity was measured by self-reported overweight status and objectively measured BMI. Unfortunately in large cohort studies, such as the one from which the data were drawn for this thesis, individuals are dispersed across a wide geographical area. As a result, it can be difficult to obtain objective measures of obesity for a large sample due to limited economic and human resources. Given the methodological limitations of collecting objective data in certain instances, a self-report measure was ideal. In the SCI population, BMI seems to be an inaccurate self-report measure.[19] Thus in Study 2, an alternate self-report measure of adiposity was used. Participants simply indicated whether they perceived themselves to be overweight. Whereas in the general population, a self-report measure of adiposity would be confounded by a variety of factors related to body image, body image concerns in the SCI population are quite low,[21] and likely do not act as confounders. The validity of this method was explored in Study 2.

2.3.3 Mechanisms of Elevated Adiposity

Following a SCI, somatic nerves are often affected leading to an immediate and sustained loss of neuotrophic influence over skeletal muscles below the level of injury. The injury results in a decrease in motor function and a subsequent and rapid atrophy of the paralysed muscle, termed obligatory sarcopenia. Specifically, during the 12 months following a SCI, total body lean tissue mass has been noted to decrease as much as 9.5%[22] while leg lean muscle mass can decrease up to 15%.[23] As muscle tissue is metabolically active, accounting for up to 85% of the variances in energy expenditure,[24] it is not surprising that a rapid decrease of muscle mass accompanies a marked decrease in overall energy expenditure.[25]

However, it is not only a loss in muscle mass that causes a decrease in energy expenditure in an individual with SCI. Decreased sympathetic nervous system activity also plays a large role in decreasing energy expenditure in the SCI population. Less sympathetic nervous system activation results in a decrease in cardiac output and oxygen consumption which directly limits energy expenditure.[26] Furthermore, it has been found that plasma catecholamine levels (e.g. epinephrine) are 300% lower in individuals with SCI than in able bodied individuals.[27] However, it is important to note that decreased sympathetic activity impacts individuals with higher thoracic and cervical level injuries to a greater extent than individuals with lower level injures.[28]

Moreover, it has been demonstrated that individuals with SCI often do not meet physical activity guidelines, nor are they as physically active as their able bodied counterparts.[29] It has also been suggested that individuals with SCI are the least physically active members of society.[30] These low levels of physical activity also contribute extensively to the depressed levels of energy expenditure and the elevated levels of adiposity and obesity reported in those with SCI.

2.3.4 Lipid and Lipoprotein Disturbances and Spinal Cord Injury

Abnormal lipid and lipoprotein profiles are associated with an increased risk of CHD in both able bodied individuals[31,32] as well as those with SCI.[33] Lipid and lipoprotein profiles are commonly assessed by quantifying low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol, and triglycerides. Table 2 provides a brief description of each lipid and lipoprotein risk factor.

Table 2. Lipid and Lipoproteins[34]

CHD Risk Factor	Characteristics
Low-density lipoprotein (LDL)	• Lipid protein complex that shuttles cholesterol from the liver to other tissues within the body. • LDL is often referred to as the "bad" cholesterol. • LDL levels above 160 mg/dL (4.1 mmol/L) are considered to be high. • Elevated LDL levels are associated with an elevated risk of CVD.
High-density lipoprotein (HDL)	• Lipid protein complex that shuttles cholesterol from the tissues to the liver for excretion and re-utilization. • HDL is often referred to as the "good" cholesterol. • HDL levels of <40 mg/dL (<1.03 mmol/L) are associated with an increased risk for CVD. • Decreased HDL levels are associated with an elevated risk of CVD.
Total cholesterol	• Total amount of all cholesterol in the blood. • Includes both LDL and HDL. • Elevated TC levels are associated with an elevated risk of CVD.
Triglycerides	• High energy fatty acids which form much of the fat stored by the body. • Elevated TG levels are associated with an elevated risk of CVD.

Combined with higher levels of adiposity and lower levels of physical activity, individuals with SCI have higher levels of plasma triglycerides and LDL,[35] lower levels of HDL,[36] and a higher prevalence of CHD[37] when compared to able bodied individuals.

2.3.5 Mechanisms of Lipid and Lipoprotein Disturbances

Higher levels of adiposity are often considered the primary mediator in these metabolic disturbances.[16] Adipocytes (fat cells) have been shown to secrete large amounts of pro-inflammatory proteins[38] negatively impacting vascular endothelium and augmenting cardiovascular disease. Elevated numbers of adipocytes also secrete non-esterified fatty acids which are usually only released during a fasted state in order to maintain blood glucose levels. The elevated level of circulating non-esterified fatty acids creates an atherogenic environment within the cardiovascular system[39] by increasing LDL levels and therefore the concentration of cholesterol and lipids in the blood.[40] It can be assumed that the lipid disturbances in individuals with SCI occur via similar mechanisms, although the processes may be augmented due to increased adiposity levels.

Finally, individuals with SCI also demonstrate increased insulin resistance[41] as well as an increased prevalence of type II diabetes compared to able bodied individuals.[42] Again, this appears to be due to the elevated levels of adiposity. Specifically, metabolites from non-esterified fatty acids appear to inhibit glucose transport into the cells[43] by inhibiting the insulin signaling cascade[44] contributing to hyperglycemia, hyperinsulinemia, and insulin resistance.

2.3.6 Role of Leisure Time Physical Activity in Decreasing CHD Risk Factors

Empirical evidence repeatedly confirms that individuals with SCI can increase their physical fitness (i.e. improve their maximal oxygen consumption)[45,46] and decrease their risk of CHD[47,48] through participation in leisure time physical activity (LTPA; activities that one chooses to do during free time such as resistance training or sporting activities). Current evidence suggests that moderate to vigorous intensity aerobic exercise, performed 3 days a week for 20-30mins is effective at improving CHD risk factors in individuals with SCI. [34]

2.3.7 Role of Activities of Daily Living

Activities of daily living (ADL) are normal day-to-day fundamental tasks which are essential to every day life. In the SCI population, ADL include activities such as wheeling, transferring (e.g. moving from the wheelchair to bed/chair/toilet), domestic tasks, and grooming activities. The positive physiological effects of ADL are unknown. To date, no research has examined the beneficial effects of increased ADL participation in the SCI population. However, studies in the SCI population have suggested that ADL do not provide similar fitness benefits as LTPA as they do not elicit the necessary heart rate elevation nor are they maintained for the duration needed to augment or even maintain physical fitness.[49] Although ADL will not augment physical fitness, there may be other possible benefits from regular participation in non-exercise physical activity such as ADL especially in the SCI population. ADL participation consists of approximately 90% of all physical activity during the day in individuals with SCI. [50] Each activity is often performed for a longer duration[51] and is often more strenuous than they would be for an able bodied individual, eliciting a higher heart rate.[48] Therefore, it could be hypothesized that any physiological benefits from ADL in the able bodied population may be amplified in the SCI population.

Among able bodied individuals, low-intensity activity such as ADL is the most variable component of energy expenditure.[52] It often accounts for the greatest proportion of activity related energy expenditure throughout the day.[53] Despite being small in magnitude, the cumulative effects of repeated low-intensity activity can have a very large effect on total energy expenditure,[54] with obesity being associated with lower levels of non-exercise physical activity such as ADL.[55,56]

Studies in animal models have also demonstrated that low-intensity activity does provide a substantial increase in lipoprotein lipase activity[57] (lipoprotein lipase; an enzyme responsible for metabolizing LDL, and controlling plasma triglycerides). Thus, the accumulation of low-intensity activity such as ADL may be a contributing factor in preventing weight gain and associated comorbidities such as CHD.[58]

Few studies have examined the positive physiological effects of non-exercise physical activity in the able bodied population and to our knowledge there is no research in this area in the SCI population. Study 1 was focused on studying the relationships between ADL participation and CHD risk factors including lipoproteins, plasma triglycerides, and adiposity.

2.4 Overweight Status, Secondary Complications, and Subjective Well-being

Although there is some evidence to support the relationships between adiposity and chronic diseases such as CHD, little is known about the relationships between adiposity, secondary complications, and SWB. The purpose of Study 2 was to examine the relationships between subjective body weight status, secondary complications, and SWB.

2.4.1 Spinal Cord Injury Specific Secondary Complications

Individuals with SCI often report SCI specific secondary complications including pressure ulcers, urinary tract infections, spasticity, bowel problems, hypotension, chronic pain, and depressive symptoms.[59,41,60,61,62] About 58% of individuals with SCI report three or more secondary complications, while only 4% of individuals report no secondary complications. [8]

2.4.2 Secondary Complications and Body Weight

Although not yet examined in the SCI population, it is hypothesized that some SCI specific complications will be associated with elevated levels of body fatness. The three specific complications which are expected to differ between individuals who do and do not consider themselves to be overweight are pain, fatigue, and overuse injuries.

The majority of individuals with SCI experience a significant amount of pain. Pain is defined by the International Association for the Study of Pain (IASP) as an unpleasant sensory or emotional experience associated with actual or potential tissue damage.[63] The prevalence of chronic pain following SCI is approximately 65%[64] with one third of individuals reporting their pain as 'severe' or 'very severe'. However the prevalence of pain after SCI also has been suggested to be much higher.[65]

The pain experienced by an individual with SCI is usually of a sufficient magnitude to interfere with daily activities, and is commonly diffuse, occurring at multiple body locations simultaneously.[66] Table 3 outlines the various types of pain often experienced by an individual with SCI. Neuropathic pain is the most common type of pain experienced by an individual with SCI.[67] Neuropathic pain is defined by the IASP as pain initiated or caused by a primary lesion or dysfunction in the nervous system.[68] Neuropathic pain involves sensory abnormalities such as shooting, aching, pricking, and tingling and may occur above, at, and/or below the level of injury. Unfortunately, this type of pain is often refractory to treatment,[69] and regular pain medication such as nonnarcotic analgesics have little or no effect. However, at least fifty new chemical entities to combat neuropathic pain are currently in clinical trials.[70]

Nociceptive pain results from activation of the peripheral nociceptors to ongoing chemical, pressure, or mechanical tissue damage. [71] Nociceptive pain may be due to either musculoskeletal or visceral disturbances. Musculoskeletal pain may be caused from overuse injuries particularly at the shoulders which is a common site for musculoskeletal pain in individuals with SCI.[72] Muscle spasms may also cause musculoskeletal pain. Pain also tends to remain stable or become worse following injury and rehabilitation.[73] While some studies have suggested that pain may be associated with various physical factors such as lesion completeness[74,75] or cause of injury (pathogenesis),[76] other studies have failed to demonstrated such relationships.[77,78,74,79]

Table 3. IASP Classification of Pain Related to SCI[80]

Type	System	Specific Structures/Pathology
Nociceptive	Musculoskeletal	Bone, joint, muscle trauma or inflammation Mechanical instability Muscle spasm Secondary overuse syndromes
	Visceral	Renal calculus, bowel, sphincter dysfunction, etc. Dysreflexic headache
Neuropathic	Above level of injury	Compressive mononeuropathies Complex regional pain syndromes
	At level of injury	Nerve root compression Syringomyelia Spinal cord trauma/ischemia (segmental deafferentation, transitional zone, border zone, girdle zone etc.)
	Below level of injury	Dual level cord and root trauma (double lesion syndrome) Spinal cord trauma/ischemia (central dysesthesia syndrome, central pain, phantom pain, etc.)

The relationship between pain and adiposity has been studied extensively in the able bodied population. A recent review suggests that the relationship between pain and adiposity has mechanical, structural, metabolic, and behavioural factors. For example, findings suggest that increased bodyweight places more stress on joints, increasing the risk of osteoarthritis.[81] Furthermore, increased body fat may have metabolic or inflammatory effects on the body thus increasing the amount of perceived pain, although these mechanisms are poorly understood.[82,83] To date, only two studies have examined the relationships between adiposity and pain in individuals with SCI.[8,83] In one study,[8] over three-hundred individuals with a multitude of SCI-related secondary complications were included in the analyses. Although increased adiposity was associated with pain, the relationships did not reach standard levels of significance (p=.08), and the author did not specify how adiposity was measured. In a second study, elevated adiposity was significantly associated with more pain in individuals with SCI,[84] however, a small sample was used (N=27), the measure of adiposity did not account for the subjective experience of being overweight, and the authors did not control for age in the models. Due to these limitations, further examination of the relationship between adiposity and pain is necessary.

Fatigue is another secondary complication that affects many people with SCI. Approximately 57% of individuals with SCI report fatigue of sufficient magnitude to interfere with daily functioning.[85] Fatigue can present as either muscular fatigue characterized by a physiological phenomenon of paralyzed muscles, or chronic fatigue which is associated with aging, and deconditioning contributing to decreased quality of life.[86]

The pathophysiology of muscular fatigue after SCI is complex but can be attributed to defective neuromuscular transmission, sarcolemma excitability, excitation–contraction coupling, intrinsic contractile properties and/or energetic metabolic supply.[87] Muscular fatigue appears to develop slowly after SCI, and this decline may be attenuated through physical activity and muscle stimulation.[85] Conversely, chronic fatigue following SCI appears to occurs earlier than muscular fatigue, and is more prevalent in individuals with tetraplegia.[85] Similar to pain, fatigue has been positively associated with adiposity in the able bodied population.[88] Although such relationships have not been examined in the SCI population, it is expected that similar relationships would be present.

Finally, overuse injuries are common among individuals with SCI. Overuse injuries are synonymous with cumulative trauma disorder and repetitive strain injuries. Overuse injuries are caused by tissue damage due to repetitive shear, tension, compression, impingement, vibration, and/or contraction forces over time. In the chronic stages of SCI, soft tissue structures are exposed to overuse on a daily basis.[89] For example, the shoulder joint in particular becomes the primary weight bearing joint during manual wheelchair propulsion and transferring.[90] Over time, the large degree of pressure in addition to an abnormal distribution of stress transmitted across the shoulder area during transfers or wheelchair propulsion, and high shoulder joint moments appear to contribute to shoulder problems and overuse injuries.[91,92] Furthermore, wheelchair propulsion has been associated with overuse injuries of the hand and wrist.[93]

In the able bodied population, increased adiposity is associated with an increase in joint and soft tissue problems.[94,95]Although no study has demonstrated an increase in overuse injuries with elevated adiposity in the SCI population, it could be hypothesized that as body weight increases, more stress is placed on the joints and soft tissue of the upper-limbs therefore increasing the stress of repetitive forces and risk of overuse injuries.

2.4.3 Adiposity and Subjective Well-being: Are they related in the Spinal Cord Injury population?

Subjective well-being (SWB) is a term used to describe a group of constructs including an individual's emotional responses, domain satisfactions, and global judgements of life satisfaction.[96] SWB also refers to an individual's subjective evaluation of his or her life and may include self-ratings of adjustment, life satisfaction, or perceived problems.[97,98] SWB has been suggested to be synonymous with perceived health status and quality of life.[99] Because SWB encompasses many constructs, the prevalence of decreased SWB in the SCI population is difficult to assess. However, a recent systematic review suggested that depression and anxiety disorders may affect up to 30% and 40% of individuals with long standing SCI respectively.[100]

Studies involving able bodied individuals have suggested a negative relationship between adiposity and SWB.[106,107] More specifically, an increase in adiposity has been demonstrated to interfere with physical, social, and emotional domains of SWB,[101] and is positively associated with depressive symptoms.[102,103] Research is needed to determine whether the relationships between adiposity and SWB demonstrated in the able bodied population also exist in the SCI population. Study 2 of this thesis will address this issue.

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CHAPTER 3. STUDY DESCRIPTIONS

3.1 Objectives and Hypotheses

3.1.1 Study 1

The primary objective of Study 1 was to determine the relationships between CHD risk factors and ADL participation. Although it is known that ADL do not provide fitness benefits, other benefits of ADL in the SCI population remain unknown. Specifically, Study 1 examined the relationships between ADL participation, and adiposity, plasma lipid and lipoprotein levels in the SCI population. Adiposity, lipid, and lipoprotein profiles are often used to approximate the risk of comorbidities such as diabetes[1] and CHD,[2,3,4] and were therefore chosen for this study. Study 1 examined if CHD risk factors were associated with ADL participation independent of LTPA participation.

The specific hypotheses of Study 1 were:

1) ADL that require larger and sustained muscle activity would be negatively associated with adiposity, LDL, total cholesterol, and TG, and positively associated with HDL, independent of LTPA participation. Such activities that would be negatively associated with CHD risk included Mobility ADL (wheeling, transferring) and Domestic ADL (cleaning).

2) Total ADL participation, independent of LTPA participation, would not be significantly associated with CHD risk.

3.1.2 Study 2

The primary objective of Study 2 was to determine the relationships between secondary complications, SWB, and perceived weight status in the SCI population. The relationships between adiposity and SWB have been established in the able bodied population. However, it remains uncertain as to whether adiposity is significantly related to SWB and secondary complications in the SCI population.

The specific hypotheses of Study 2 were:

1) Individuals who considered themselves to be overweight were more likely to report other secondary complications particularly fatigue, overuse injuries, and pain than individuals who do not consider themselves to be overweight.

2) Individuals who considered themselves to be overweight would have lower SWB, including satisfaction with life and depressive symptoms than individuals who did not consider themselves to be overweight.

3) Objectively measured adiposity (BMI) would not be related to secondary complications or SWB.

3.2 Study Design and Methods

Data were obtained from the Study of Health and Activity in People with Spinal Cord Injury (SHAPE-SCI).[5] The SHAPE-SCI study is a multi-disciplinary and multi-institutional study of physical activity and health in people who have incurred a SCI. Currently, the study has obtained longitudinal data from six-hundred and ninety-five (n=695) men and women with SCI from four SCI centers including Chedoke-McMaster (Hamilton), Lyndhurst (Toronto), Parkwood (London), and St. Mary's on the Lake (Kingston). The data were stored at McMaster University, in Hamilton Ontario, and were extracted for statistical analyses at Queen's University.

A subsample (n=75) was used for Study 1 analyses. The sample size was limited by the subsample of participants in the SHAPE-SCI who had completed CHD risk factor blood sampling, anthropometry, and body composition measurements. Ideally, the SHAPE-SCI was to include 81 participants in the subsample. This sample size was adequate to detect a R^2 of .10 in all CHD risk factors which is the smallest effect considered of clinical or substantiate significance with 80% power (α=.05).[51] According to Cohen,[6] a sample size of 81 would have also been sufficient to detect a medium to large effect size, with 80% power (α=.05). However, only 75 individuals were available to be recruited. For Study 2, the entire SHAPE-SCI sample was included, except for analyses involving BMI in which the subsample was used.

3.3 Ethical Considerations

Ethics approval has been obtained from each medical research ethics board at each participating institution.

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CHAPTER 4. MANUSCRIPT 1

Increased ADL participation is associated with lower cholesterol levels in individuals with spinal cord injury

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Increased ADL participation is associated with lower cholesterol levels in individuals with spinal cord injury

Abstract

Objective: To evaluate the relationships between ADL participation and coronary heart disease (CHD) risk factors in individuals with SCI.

Design: Cross-sectional.

Setting: Hamilton, Ontario, Canada.

Participants: 61 men and 14 women (N=75) participants from the SHAPE-SCI study.

Interventions: Not applicable.

Main Outcome Measures: Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI) and CHD risk factor assessment including waist circumference, total cholesterol, LDL-cholesterol (LDL), HDL-cholesterol (HDL), and triglycerides.

Results: Using generalized linear models, controlling for leisure time physical activity and covariates, increased Mobility ADL (transferring and wheeling) were associated with lower plasma total cholesterol and LDL. No other significant relationships emerged.

Conclusion: Mobility ADL were associated with lower total cholesterol and LDL. However, neither Total ADL nor Domestic ADL were associated with CHD risk. Further investigation is needed to determine causality between Mobility ADL and CHD risk.

Key Words: Activities of daily living, non-exercise physical activity, coronary heart disease risk factors, spinal cord injury, SHAPE-SCI

Introduction

Total daily energy expenditure is greatly attenuated in individuals with long standing spinal cord injury (SCI). This decrease in energy expenditure is mainly attributed to a decrease in metabolically active fat-free mass[1] as well as a decrease in physical activity.[2] Not surprisingly, decreased energy expenditure in individuals with SCI is paralleled by elevated levels of adiposity and coronary heart disease (CHD).[3] Moreover, individuals with SCI have a higher prevalence of obesity and CHD when compared with able bodied counterparts.[4] However, participation in leisure time physical activity (LTPA) such as resistance and aerobic training has been shown to be efficacious at lowering CHD risk factors in those with long standing SCI.[5]

Similar to LTPA participation, activities of daily living (ADL; normal day-to-day fundamental tasks which are essential to every day life, such as mobility and domestic related activities) have been suggested to play a significant role in total daily energy expenditure.[6] ADL often accounts for the greatest proportion of activity related energy expenditure throughout the day.[6] Despite being brief in duration, the cumulative effects of repeated bouts of ADL can have a very large effect on total energy expenditure.[7] In the able bodied population, obesity is associated with lower levels of non-exercise related activities such as ADL.[8,9]

In addition, lifestyle physical activity programs which include ADL (i.e. accumulating activity in small bouts throughout the day), have demonstrated positive effects such as decreased adiposity similar to structured exercise interventions.[10] In the SCI population, the benefits of ADL participation are unclear. It remains to be determined whether ADL participation, independent of LTPA, is associated with decreased CHD risk factors. Therefore, the primary purpose of this study was to examine the relationships between total daily ADL participation (Total ADL) and CHD risk factors including waist circumference, total cholesterol, LDL-cholesterol (LDL), HDL-cholesterol (HDL), and triglycerides in the SCI population.

Within the SCI population, ADL including personal care, domestic, and mobility activities constitute approximately 90% of all physical activity during the day.[11] Each ADL is often performed for a longer duration,[12] is more strenuous, and elicits a higher heart rate than for an able bodied individual.[13] There is wide variation in the physical demands of various types of ADL. ADL which require larger and more sustained muscle contractions (e.g. mobility activities such as transferring) appear to elicit greater heart rate responses than less demanding ADL such as personal care activites.[13] Given the physical demands of strenuous ADL, it is likely that these activities are associated with reduced risk of CHD. Conversely, many ADL such as desk and office work and personal care activities are sedentary and are likely to have a weak or positive relationship with CHD risk factors.[14] In turn, these weak or positive relationships are likely to offset any significant negative relationships between more rigorous ADL such as mobility related activities and CHD risk factors during statistical analyses. Given this variation in ADL patterns we hypothesized that Total ADL participation would be unrelated to CHD risk factors.

As a secondary objective we examined the relationships between Mobility and Domestic ADL, and CHD risk factors. We focused on these two types of activities because they are often the most physically demanding ADL for individuals with SCI[13] and have been suggested to constitute the majority of ADL throughout the day.[15] Thus, we hypothesized that Mobility and Domestic ADL categories would demonstrate negative relationships with CHD risk factors.

Materials and Methods

This study involved an analysis of seventy-five individuals who participated in the Study of Health and Activity in People with Spinal Cord Injury (SHAPE-SCI).[16] Participants completed the Physical Activity Recall Assessment for People with SCI (PARA-SCI) as well as a biometric evaluation consisting of venous blood sampling and waist circumference measurements. All biometric data were collected within 14 days of the PARA-SCI in the participants' homes.

Participants

The sample size was limited to those individuals who had completed a biometric evaluation for cardiovascular disease risk factors. A full list of measurements as well as inclusion and exclusion criteria of the SHAPE-SCI are reported elsewhere.[16] Briefly, study inclusion criteria included (a) traumatic SCI etiology, (b) ≥ 18 years of age, (c) assistance required for mobility (manual or power wheelchair, walker, braces, cane), (d) SCI years post injury >12 month, (e) proficient in reading and speaking English, (f) reside within 200km of McMaster University, (g) able to transfer themselves with assistance between wheelchair and bed, and (h) no cognitive or memory impairments . Participant demographic characteristics are presented in Table 1. All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

Activities of Daily Living

The PARA-SCI[17] is a self-report measure of all activities performed over a 3-day recall period. The PARA-SCI is administered via telephone using a consistent and structured interview protocol. Participants reported the specific activity, duration, and intensity of both ADL and LTPA according to the PARA-SCI guidelines. Consistent with the PARA-

SCI protocol (Martin Ginis KA & Latimer AE. PARA-SCI Administration and Scoring Manual. Hamilton, ON, McMaster University. 2008), activities reported to require no physical effort were not recorded. Specific ADL scores for each activity were calculated by summing the time spent engaged in mild-, moderate-, and heavy-intensity ADL. The detailed definitions of these intensity levels have been reported elsewhere.[17] In addition to providing a better representation of ADL participation, combining the three intensity levels also increased statistical power by limiting the number of subsequent models and decreased the likelihood of a type I error.[15] The ADL component of the PARA-SCI has demonstrated reliability[15] and validity.[11] ADL scores from the PARA-SCI are associated with fitness level (VO_{2max}) and differentiate between injury level.[15]

Similar to past analyses using the PARA-SCI ADL scores,[15] activities which required similar functional movements were clustered. For example, activities involving personal care (e.g., washing face, brushing teeth, and brushing hair) were clustered into the 'grooming' category. Clustering the activities was essential for further analysis, as most individually reported ADL (e.g. brushing hair) had minimal participation.

Furthermore, wheeling and transferring were combined into the 'Mobility ADL' class, while cleaning, food preparation, laundry, and yard work were further combined into the 'Domestic ADL' class. This further categorization helped to increase statistical power and provides more generalizable information regarding a class of activities (e.g. mobility and domestic activities) rather than specific activities (e.g. mopping the floor).

Although very sedentary activities such as desk and office work and personal care activities were included in Total ADL analyses, they were excluded from further analyses because they are more similar to sedentary sitting than to physical activity. Furthermore, increased time spent involved in personal care activities (grooming, bathing, and toileting) often involves assistance from a personal support worker or family member. Therefore, increased participation in personal care ADL may be indicative of physical disability rather than increased physical activity.

Biometric Data

As described elsewhere,[18] venous blood was extracted from a forearm vein and collected into empty vacutainer tubes. The samples were stored on ice after being collected and were transported to the laboratory for analysis on the same day (McMaster Medical Centre Department of Laboratory Medicine). Blood was centrifuged for 15 minutes at 3000 revolutions per minute before chemical analysis. HDL, total cholesterol, and triglycerides were quantified using a homogeneous enzymatic colorimetric test (Roche Modular ISE 1800, Roche, Laval, Québec). LDL was quantified indirectly using the Friedewald equation.[19] Waist circumference was measured around the lowest rib in centimeters to the nearest decimal place using a non-elastic, flexible measuring tape.[20] Waist circumference was measured while the participants were supine with arms abducted 30º from midline and following normal expiration. Waist circumference was measured in duplicate and averaged if the difference was ≤5%; if ≥5%, a third measurement was made and the two closest measurements were averaged.

Data Screening

Seventy-five participants completed both the PARA-SCI as well as biometric sampling. However, 18 of these participants did not adhere to the 10-hour fasting protocol, and were subsequently excluded from plasma variable analysis. Preliminary analysis revealed that the excluded participants did not differ from the included participants in demographic characteristics, biometrics, or ADL activity ($p>.05$). All seventy-five participants were included in the waist circumference analyses.

Statistical Analyses

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS version 16.0, Chicago, IL). In order to identify potential covariates to include in our analysis, relationships between biometric variables and demographic characteristics such as age, years post injury, injury level, mode of mobility, and gender were examined using analysis of variance (ANOVA) for categorical data and Pearson's bivariate two-tailed correlations for continuous data.

Generalized linear models (GLM) were employed to test the relationships between biometric data and ADL participation while controlling for LTPA and other relevant covariates. Separate GLM were used to test the relationships between each biometric indicator (e.g., waist circumference, triglycerides) and ADL. Covariates and the predictor variable (e.g., Total ADL) were entered into the model together. GLM was selected as the analyses method because it is appropriate for use with data which does not assume a normal distribution. In the GLM normal distributions were selected for all dependent variables except for triglycerides and HDL. For these two variables, a gamma distribution was specified because they both demonstrated a positive skew. In addition to examining the relationships between CHD risk factors and Total ADL participation, additional analyses were conducted to examine the relationships between CHD risk factors, Mobility ADL, and Domestic ADL. The remaining ADL, although included in Total ADL analyses were not further evaluated as the purpose was to examine ADL which were primarily not sedentary.

Results

Covariates

Significant sex differences (p<.05) emerged for HDL (*F*=12.11, *df*=1, *p*=.001). Women had higher HDL levels than men. Age was positively associated with increased waist circumference (*r*=.34, *p*<.01). Finally, triglycerides were positively associated with alcohol consumption (*r*=.40, *p*<.01). These differences were controlled for in subsequent analyses in addition to LTPA participation. No other significant differences or associations emerged.

ADL Participation

Participants spent an average of 118.81±121.29 minutes per day (min/day) engaged in Total ADL (Range= 0.00min/day to 468.83min/day). More specifically, participants spent 17.35±27.07 min/day engaged in Mobility ADL (Range= 0.00min/day to160.03min/day), and 15.78±30.45 min/day engaged in Domestic ADL (Range= 0.00min/day to 150.00min/day). The remaining ADL time consisted primarily of personal care and desk and office work activities.

Biometric Data

Biometric results are reported in Table 2. The relationships between ADL participation and biometric data are reported in Table 3. Each relationship was examined using a unique GLM. Moreover, due to three relationships being examined for each CHD risk factor, a Bonferroni correction was employed such that the *p*-value was set at .016.

Total ADL

In the models controlling for covariates and LTPA, Total ADL participation was not related to any CHD risk factors (*p*>.016).

Mobility ADL

In the models controlling for covariates and LTPA more time spent engaged in Mobility ADL was associated with lower LDL (p=.001) as well as lower total cholesterol (p=.005). No significant relationships emerged between Mobility ADL and HDL, triglycerides, or waist circumference (p>.016).

Domestic ADL

In the models controlling for covariates and LTPA, Domestic ADL participation was not related to any CHD risk factors (p>.016).

Discussion

It has been well established that individuals with SCI spend a great deal of time participating in ADL.[11] However, there is limited evidence supporting the potential beneficial effects of ADL in decreasing the risk of CHD. The current study examined the relationships between ADL and CHD risk factors in individuals with chronic SCI. Interestingly, Mobility ADL but not total or Domestic ADL were associated with reduced CHD risk. These findings have important implications for practice and research.

As hypothesized, Mobility ADL were associated with lower total cholesterol and LDL. The specific physiological mechanisms underlying the study findings are complex and poorly understood.[21] The aerobic characteristics of Mobility ADL may have contributed to these findings. It has been suggested that aerobic activities may be more effective than resistance training at decreasing LDL and total cholesterol.[22] Interestingly, a study from the SHAPE-SCI,[18] using the same data set as the one in the present study, did not find significant relationships between LTPA and total cholesterol and LDL. The discrepancy between study findings indeed may be the result of the aerobic nature of Mobility ADL[23] compared to LTPA which often includes both aerobic and anaerobic activities (e.g. resistance training).[16]

Another possible mechanism that should be considered is the role of lipoprotein lipase (LPL) in LDL uptake. Physical activity, even in low amounts has demonstrated to increase LPL activity, [24] which may increase the cellular uptake of LDL.[25] This enhancement of LPL activity may help to partially explain the negative relationships between LDL and mobility related activity in this study. Additional research using a longitudinal design is needed to understand the underlying mechanisms of such processes, as well as determine causality between ADL activity and depressed CHD risk factors.

Also in accordance with our hypotheses, Total ADL were also unrelated to CHD risk factors. Total ADL encompasses very sedentary activity such as desk and office work. These sedentary activities likely weakened the relationships between ADL and CHD risk factors. Although the relationships between Domestic ADL, and LDL and total cholesterol approached significance, we were unable to demonstrate the expected relationships between these variables. It is possible that Domestic ADL are not performed for the same duration as the majority of Mobility ADL. For example, ADL wheeling may be performed extensively throughout the day as the primary mode of mobility. Furthermore, it may be that Mobility and Domestic ADL differ in the amount of physical exertion required to accomplish these tasks.[13] Domestic ADL such as preparing food has been found to be much less strenuous than Mobility ADL such as transferring into an automobile.[13]

Contrary to the hypotheses, Mobility ADL were not associated with waist circumference and triglycerides. Short bouts of non-exercise physical activity, such as ADL have demonstrated to be negatively associated with waist circumference and triglycerides in the able bodied people.[26] Although Mobility ADL were associated with lower LDL and total cholesterol, we were not able to demonstrate similar findings with the other biometric indicators. The inconsistencies between our study and previous research examining the relationship between short bouts of non-exercise physical activity and CHD risk factors may be due to the different measurement tools used between studies (objective vs. self-report) or indicative of the sample population (able bodied individuals vs. individuals with SCI). Moreover, it is quite possible that the SCI specific ADL performed by the current sample were not of adequate intensity or duration to affect certain biomarkers.

Taken together, our study findings have interesting implications for future research. ADL are often classified under an umbrella term called "non-exercise activity thermogenesis" (NEAT). NEAT has been defined as all non-exercise energy expenditures, including incidental movement, ADL, maintenance of muscle tone and posture, fidgeting, and shivering.[6] In the few studies conducted in the able bodied population, lower levels of NEAT have been associated with obesity[27] and CHD.[28] NEAT has not been examined in the SCI population. Our study findings help to support the notion of the importance of considering specific components of NEAT such as Mobility ADL when examining CHD risk factors.

By classifying and examining SCI specific ADL, our preliminary findings suggest that increased Mobility ADL participation may be a strategy worth investigating as a means of decreasing CHD risk factors, particularly LDL and total cholesterol in individuals with SCI.

Limitations

Despite extending the current literature regarding the relationships between ADL activity and CHD risk factors the study was limited. We expected to find a greater number of negative relationships between Mobility and Domestic ADL, and CHD risk factors. The lack of evidence supporting these hypotheses may be indicative of the minimal amount of time participating in these ADL classes (<18min per day). Increased participation in Mobility and Domestic ADL as seen in previous studies[15] may have elicited a greater number of significant negative relationships with CHD risk factors. Second, because 24% of participants did not adhere to the fasting protocol, our sample size was limited. With a small sample size and large standard deviations, the likelihood of a type II error is increased. Thus, future studies should examine these relationships using a larger study sample and longitudinal design. Finally, although the PARA-SCI has demonstrated validity[11] and reliability,[15] due to the self-reported nature of the tool, it was necessary to use subjective temporal measure (min/day) of ADL as opposed to an objective measure such as oxygen consumption or accelerometry.

Conclusion

This study examined the relationships between ADL activity and CHD risk factors among individuals with SCI. Mobility ADL were associated with reduced CHD risk. Increased Mobility ADL should be further investigated as a possible method to decrease LDL and total cholesterol levels in individuals with SCI.

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Table 1. Participant Demographic Characteristics [Frequency (%)]

	N=75
Age (yrs)	42.39±11.78*
Years post injury[†]	14.94±10.57*
Sex	
Men	61 (81.3%)
Women	14 (18.7%)
Level of Injury	
Paraplegia	38 (50.7%)
Tetraplegia	37 (50.3%)
Type of Mobility	
Manual wheelchair	53 (71.6%)
Power wheelchair	17 (23.0%)
Ambulate	4 (5.5%)
Marital Status	
Single	41 (54.7%)
Married/common Law	34 (45.3%)

*Mean±SD

[†]One participant was missing *Years post injury* information

Table 2. Participant Biometric Data

	N	Mean±SD
HDL Cholesterol Levels (mmol/l)	53	1.21±.32
LDL Cholesterol Levels (mmol/l)	51	2.80±.99
Total Cholesterol Levels (mmol/l)	53	4.73±1.03
Triglycerides (mmol/l)	54	1.56±.92
Waist Circumference (cm)	75	91.23±13.96

Table 3. Biometric and ADL Relationships

	Total ADL	Mobility ADL	Domestic ADL
HDL*			
Beta	-3.32×10^{-5}	.00	-1.60×10^{-5}
Wald Chi-Square	.13	2.28	.00
p-value	.72	.13	.96
LDL†			
Beta	.00	-.005	-.002
Wald Chi-Square	1.40	10.96	3.30
p-value	.24	.001	.07
Total Cholesterol†			
Beta	.00	-.005	-.002
Wald Chi-Square	1.94	7.79	2.81
p-value	.16	.005	.09
Triglycerides‡			
Beta	-5.35×10^{-5}	.001	.000
Wald Chi-Square	.026	.44	.12
p-value	.87	.51	.73
Waist Circumference§			
Beta	.007	.034	.016
Wald Chi-Square	2.45	3.27	.93
p-value	.12	.07	.34

* Controlling for sex and LTPA

† Controlling for LTPA

‡ Controlling for alcohol consumption and LTPA

§ Controlling for age and LTPA

CHAPTER 5. MANUSCRIPT 2

Secondary complications and subjective well-being in individuals with chronic spinal cord injury: Associations with self-reported adiposity

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Secondary complications and subjective well-being in individuals with chronic spinal cord injury: Associations with self-reported adiposity

Abstract

Objective: To examine the associations between adiposity, secondary complications, and subjective well-being (SWB) in individuals with spinal cord injury (SCI).

Design: Cross-sectional.

Setting: Parkwood Hospital (London); Hamilton Health Sciences-Chedoke Site and McMaster University (Hamilton); Lyndhurst Hospital and Toronto Rehabilitation Institute, Lyndhurst Centre (Toronto); and St Mary's of the Lake Hospital and Queen's University (Kingston), Ontario, Canada.

Participants: 531 men and 164 women (N=695) participants from the Study of Health and Activity in People with Spinal Cord Injury (SHAPE-SCI).

Interventions: Not applicable.

Main Outcome Measures: A survey of secondary complications, where participants identified the health complications they had experienced secondary to SCI (including perceptions of being overweight) and the impact of these complications on their daily lives, objectively determined Body Mass Index (BMI), and SWB including satisfaction with life and depressive symptoms.

Results: Controlling for covariates, individuals who perceived themselves to be overweight were more likely to report overuse injuries and fatigue, experienced a greater impact of overuse injuries and fatigue, had greater pain and depressive symptoms, and had lower satisfaction with life than individuals who did not perceive themselves to be overweight. BMI was not associated with secondary complications or SWB.

Conclusion: Perceived overweight status was associated with an increased prevalence of certain secondary complications and lower SWB. Future prospective studies should examine whether reductions in adiposity are associated with a decrease in the prevalence and the impact of secondary complications and an increase in SWB.

Key Words: Overweight, adiposity, spinal cord injury, secondary complications, pain, satisfaction with life, depression, subjective well-being

Introduction

One of the most prevalent comorbidities reported after spinal cord injury (SCI) is an increase in adiposity due to both a decrease in basal metabolic rate[1] and a sedentary lifestyle.[2] Approximately 66% of individuals with SCI are considered overweight or obese.[3] Due to measurement limitations of adiposity measurements (specifically Body Mass Index; BMI), this statistic likely underestimates the true prevalence of overweight and obesity in the SCI population.[4] In both the able bodied and the SCI populations, excess body fat has been associated with an elevated risk of many chronic diseases including but not limited to cardiovascular disease, diabetes, and musculoskeletal problems.[5,6,7]

In addition to chronic diseases, individuals with SCI report a myriad of injury related comorbidities and complications including bladder problems, pressure sores, pain, spasticity, and fatigue.[8,9] It has been suggested that up to 95% of individuals with SCI currently have at least one secondary complication, while the majority of these individuals (58%) have three or more complications.[9] However, what remains unknown is whether elevated adiposity (i.e. body fatness, overweight) is associated with these secondary complications frequently experienced by individuals with SCI.

Two common secondary complications which may be associated with adiposity in individuals with SCI are pain and overuse injuries. Pain and overuse injuries of the upper limb joints have been reported to affect over 72% of individuals with SCI.[10] In the able bodied population, elevated body fat has been linked to osteoarthritis[11] and cartilage degradation[12] of the weight bearing joints which may also increase pain. Given the unique mobility activities performed by individuals with SCI (i.e. wheelchair propulsion, transferring), increased adiposity may be associated with overuse injuries and pain of the upper limb joints as these structures may be subjected to greater strain as body weight increases.[13,14]

Fatigue is another commonly reported complication that may be associated with adiposity in individuals with SCI. Fatigue has been suggested to affect approximately 57% of individuals with SCI.[15] In the able bodied population, elevated adiposity has been related to an increase in fatigue due to physiological, psychological, and sleep disturbances.[16] Although not yet examined in the SCI population, it was expected that individuals who considered themselves to be overweight would report greater fatigue than individuals who did not report being overweight.

In addition to having implications for physical health, elevated adiposity also may be associated with subjective well-being (SWB) in the SCI population. SWB is a term often used to describe a group of constructs including an individual's emotional responses, domain satisfactions, and global judgments of life satisfaction.[17] For the purpose of this study, both depression and satisfaction with life were considered measures of SWB. In the able bodied population, obesity is associated with poorer SWB.[18,19,20,21] However, the relationships between adiposity and SWB have not been examined in the SCI population. It was hypothesized that similar to the findings from the able bodied population, individuals with SCI who perceive themselves to be overweight would report lower levels of SWB than individuals who do not report being overweight.

The primary purpose of this study was to examine the relationships between adiposity, secondary complications associated with SCI, and SWB. In the current study adiposity was operationalized using both objective and subjective measures. For the objective assessment of adiposity, measured height and weight were used to calculate BMI (weight in kg/height in m^2).[22] For the subjective measure, participants indicated whether they perceived themselves to be overweight. These two measures were used to examine the relationships between adiposity, secondary complications, and SWB because it has been suggested that objective measures are often poor predictors of perceived health and well-being.[23,24]

BMI seems to be an inadequate measure of adiposity in the SCI population.[4] Given the inaccuracy of BMI particularly for the SCI population, we hypothesized that the relationships between adiposity, secondary complications, and SWB would only emerge for self-reported adiposity. Indeed, past research has demonstrated that subjective measures of physical functioning and health are more accurate predictors of subjective well-being outcomes compared to objective measures.[23,24] Thus, it was hypothesized that individuals who considered themselves overweight would have an increased prevalence of other secondary complications particularly pain, fatigue, and overuse injuries. Furthermore, it was expected that individuals who considered themselves overweight would have significantly lower levels of satisfaction with life and greater depressive symptoms.

Material and Methods

This study involved an analysis of data from 695 individuals who participated in the Study of Health and Activity in People with Spinal Cord Injury (SHAPE-SCI).[25] The SHAPE-SCI is a multi-centre, prospective study examining health and daily activity levels in people who have experienced a traumatic SCI. Participants completed the Secondary Complications Survey, SF-36 pain subscale,[26] Satisfaction with Life Scale (SWLS),[27,28] and the Patient Health Questionnaire-9 (PHQ)[29] via the telephone. BMI measurements were obtained from a subsample of the SHAPE-SCI participants (n=73) within 14 days of the telephone interview.

Participants

The study sample included all 695 participants enrolled in the SHAPE-SCI. Participant demographic characteristics are presented in Table 1. Six-hundred and ninety-five participants were included in all analyses except for those involving BMI in which the SHAPE-SCI subsample was used. A full list of measures as well as inclusion and exclusion criteria of the SHAPE-SCI are reported elsewhere.[26] Briefly, study inclusion criteria included (a) traumatic SCI etiology, (b) ≥ 18 years of age, (c) assistance required for mobility (manual or power wheelchair, walker, braces, cane), (d) SCI years post injury >12 month, (e) proficient in reading and speaking English, (f) no self-reported cognitive or memory impairments. All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

Measures

Secondary Complications: The Secondary Complications Survey provides participants with a list of 13 common secondary complications. By responding “yes” or “no,” participants indicate whether they had experienced each complication listed within the past six months. The impact each complication had on participants’ daily life in the past six months was also assessed on a 5-point scale (0= none at all; 4= very severe impact). The secondary complications examined included overweight, spasticity, overuse injuries, fatigue, urinary tract infection (UTI), respiratory infection, pressure sores, osteoporosis, broken bones or joint dislocations, blood clots or deep vein thrombosis (DVT), and other infections. A “yes” response to overweight was used as an indicator of adiposity.

Using the subsample from the SHAPE-SCI (n=69-73*) we conducted exploratory analyses to examine the discriminant validity of the perceived overweight item. Individuals who reported themselves to be overweight as indicated by the Secondary Complications Survey had a higher BMI (31.57±9.2 kg/m^2 vs. 23.4±3.5 kg/m^2), $F(1,70)=58.49$, $p<.001$, waist circumference measured at the point between the iliac crest and lowest rib (105.36±2.70cm vs. 86.69±1.59cm), $F(1,72)=35.50$, $p<.001$, and fat percentage (33.4±2.0% vs. 26.3±1.2%), $F(1,67)=9.52$, $p<.003$ measured by bioelectrical impedance compared to individuals who reported themselves not overweight.

Pain: Pain was assessed using the 2-item pain subscale of the SF-36.[26] Respondents reported the severity of their pain on a 5-point scale (0= none; 4= very severe) and the impact of pain on their daily life on a 6-point scale (0= none; 5= extremely). This subscale has been validated to provide an indicator of overall pain perception,[30] and has been previously used in the SCI population.[31]

Subjective Well-being: SWB was assessed using the SWLS[27,28] and the PHQ-9.[29] The SWLS is a global measure of an individual's cognitive judgments of satisfaction with their life which asks participants to answer 5 questions on a 7-point likert scale (1= strongly disagree; 7=strongly agree). The 5-item scale has been previously validated,[32] demonstrated high internal consistency (Cronbach's α= .84), and has previously been used in the SCI population.[33] The PHQ-9 is an indicator of depressive symptoms which asks participants to answer 9 questions on a 4-point scale (0= not at all; 3= every day). The 9-item scale has been previously validated,[29] demonstrated high internal consistency (Cronbach's α= .80), and has been previously used in the SCI population.[34]

* *Number of participants differed due to incomplete data.*

Body Mass Index: BMI was calculated by weight in kilograms divided by height in meters-square. Height and weight measurements were obtained by a trained research assistant in the participants' home. Weight was taken using a portable, digital, wheelchair scale (Health O Meter 2450KL, Brooklyn, NY). Participant's height was then measured in a supine position while on a spine board using a flexible, non-elastic tape measure (Gulick II Tape Measure, Gay Mills, WI).

<u>Statistical Analyses</u>

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS version 16.0, Chicago, IL). In order to identify potential covariates to include in our analysis, relationships between secondary complications, SWB, and demographic characteristics were examined using analysis of variance (ANOVA) for categorical data and Pearson's bivariate two-tailed correlations for continuous data. A *p*-value less than .05 was considered statistically significant.

To test our hypotheses, a series of three statistical tests were used. It was necessary to use multiple approaches to accommodate for categorical and continuous outcome variables and to control for covariates. First, to test the relationship between adiposity (subjective and objective) and the occurrence of secondary complications, we conducted separate logistic regressions on each secondary complication that was assessed as a dichotomous outcome (yes/no). Second, to test the relationships between adiposity and both pain and SWB, we conducted separate ANOVAs for the subjective measure of adiposity, and partial correlation for the objective measure of adiposity. Finally, we conducted separate ANOVAs to examine the relationship between subjective adiposity and the impact of each secondary complication, and partial correlations to examine the relationship between objective adiposity and the impact of each secondary complication.

Results

Covariates

While all demographic variables were examined as possible covariates, only age, years post injury (YPI), sex, mode of mobility, and injury severity were found to be associated with certain secondary complications, adiposity, or SWB measures. Thus in all subsequent analyses, the demographic variables that demonstrated a significant association with a predictor or outcome variable were included as covariates (see Table 2).

Overweight Status and Secondary Complications

Readers are referred to Table 2 for descriptive statistics. After controlling for relevant covariates, the logistic regression models predicating overuse injuries and fatigue were significant (Homer & Lemeshow Tests ≥.21). Individuals who considered themselves overweight were more likely to report overuse injuries (Adjusted OR 1.58 (95%CI=1.13-2.21), Wald=6.98, p=.008), and fatigue (Adjusted OR 1.65 (95%CI=1.18-2.33), Wald=8.35, p=.004) than individuals who did not consider themselves overweight. ANOVAs also confirmed that individuals who were overweight reported an increase in the impact of overuse injuries, $F(1,644)=13.80$, $p<.001$, fatigue, $F(1,648)=9.21$, p=.003, and significantly higher pain, $F(1,648)=4.68$, p=.03, than individuals who did not consider themselves overweight. Perceived overweight status was not related to any other secondary complications.

Overweight Status and Subjective Well-Being

ANOVAs confirmed that individuals who were overweight had significantly greater depressive symptoms $F(1,682)=11.27$, $p=.001$, and lower satisfaction with life, $F(1,669)=3.91$, $p=.05$, than individuals who did not consider themselves overweight.

Body Mass Index

Logistic regression revealed that BMI was not associated with secondary complications. Partial correlations indicated that increased BMI was not associated with the impact of any secondary complication, satisfaction with life or depressive symptoms.

Discussion

In able bodied individuals, being overweight has negative implications for both physical and psychosocial well-being.[35] However, there has been limited research examining the relationships between adiposity, secondary complications, and SWB in individuals with SCI. Our findings suggest that individuals who perceive themselves to be overweight also experience greater fatigue, overuse injuries, pain, depression, and lower satisfaction with life than those who do not consider themselves overweight.

As hypothesized, individuals who perceived themselves to be overweight reported a greater prevalence and impact of overuse injuries, fatigue, and pain than individuals who did not consider themselves overweight. Among people with SCI, the upper limbs often support the body weight especially during activities of daily living (ADL) such as wheelchair propulsion and transferring. Such ADL place an increase strain on the upper limb joints which may explain the relationships between being overweight, overuse injuries, and pain in this sample.[36] Furthermore, it has been suggested that elevated levels of body fat may promote the release of proinflammatory cytokines[37] which intern also may exacerbate pain.[38,39] Not surprisingly, perceived adiposity was not related to other secondary complications such respiratory infections or UTIs. These relationships help provide evidence of the specificity of the Secondary Complication Survey and support its validity.

The hypothesis that individuals who perceived themselves to be overweight would report less favorable SWB than individuals who did not perceive themselves to be overweight also was supported by the findings from this study. Increased adiposity has been associated with poorer measures of SWB including physical and psychological well-being in the able bodied population.[40] Therefore it is not surprising that we found that individuals with SCI who considered themselves to be overweight reported less satisfaction with life and greater depressive symptoms than individuals who did not consider themselves to be overweight. Increased adiposity has been shown to limit ADL participation in the able bodied population.[41] Likewise, those who report being overweight may have encountered greater limitations in accomplishing ADL or community integration therefore becoming less satisfied with their life.[42,34] Moreover, there is empirical evidence that elevated levels of body fat alone may contribute to increased depressive symptoms.[43] The relationship between being overweight and depressive symptoms may be due to differing physical activity levels, nutrient intake, and self-esteem.[44,45]

As hypothesized, objectively measured BMI was unrelated to secondary complications and satisfaction with life. The null relationships were expected, as BMI is unable to differentiate between fat- and fat-free mass and has been suggested to be a poor surrogate for adiposity especially in the SCI population.[4] Moreover, it has been suggested that objective measures of health status (BMI) may not predict perceived health and well-being as well as subjective measures (perceived overweight status).[25]

Limitations

Despite extending the current literature regarding the associations between secondary complications associated with SCI and SWB, our study was limited. First, the subjective measure of adiposity and secondary complications require further validation. We indeed have supported the validity of the adiposity component of the Secondary Complications Survey by demonstrating that individuals who considered themselves to be overweight had a significantly higher BMI, waist circumference, and body fat percentage than individuals who did not consider themselves overweight. However, further rigorous validation of the Secondary Complications Survey is needed. Second, the SHAPE-SCI subsample used in the current study for the BMI related analyses was small in comparison to the larger cohort. This smaller sample size possibly decreased statistical power, and may have contributed to the non-significant findings between BMI, secondary complications, and SWB. The 2-item pain subscale from the SF-36 is unable to differential between neuropathic and musculoskeletal pain. Future studies examining the relationships between adiposity and pain should use a measure which is able to predict both the type and location of pain. There is also concern that individuals who report being overweight may also have a tendency to report other secondary complications without reservation. However, as perceived adiposity was only associated with hypothesized secondary complications, it seems that individuals responded to the survey accurately. Finally, due to the cross-sectional nature of the study, we are unable to determine causality or directionality of the examined relationships.

Conclusion

Using a subjective measure of overweight status appears to reveal a greater number of differences in secondary complications and is more predictive of subjective well-being than objectively measured BMI. Using subjective measures of overweight status should be further explored as a possible method for gaining an understanding of adiposity and its impact on secondary complications and SWB in the SCI population in large cohorts.

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Table 1. Participant Demographic Characteristics

	N	
Age (Mean±SD)	694	46.83±13.42 yrs
Years post injury (Mean±SD)	692	15.29±11.10 yrs
Sex n(%)	695	
Men		531 (76.4%)
Women		164 (23.6%)
Impairment n(%)	678	
Paraplegia		320 (47.2%)
Tetraplegia		358 (52.8%)
Injury Severity n(%)	686	
C1-C4, ASIA A, B, C		75 (10.8%)
C5-C8, ASIA A, B, C		184 (26.5%)
T1-S5, ASIA A, B, C		255 (36.7%)
AISA D at any level		172 (24.7%)
Type of Mobility n(%)	695	
Manual wheelchair		389 (56.0%)
Power wheelchair		221 (31.8%)
Ambulate with assistive device		85 (12.2%)

Table 2. Overweight Status, Secondary Complications, and SWB

	Perceived Overweight	
	Yes (N=209)	No (N=483)
Overuse Injuries[1,2,4] n(%)**	115 (55.0%)	213 (44.1%)
Impact of Overuse Injuries[1,2] (Mean±SD)***	1.77±1.18	1.27±1.02
Fatigue[1,3] n(%)**	138 (66.0%)	263 (54.5%)
Impact of Fatigue[1] (Mean±SD)**	1.93±.12	1.54±1.14
Spasticity[1,4] n(%)	151 (72.2%)	364 (75.4%)
Impact of Spasticity[1,4] (Mean±SD)	2.42±1.10	2.45±1.14
UTI[1,4,5] n(%)	129 (61.7%)	286 (58.8%)
Impact of UTI[1] (Mean±SD)	2.42±1.12	2.63±.1.17
Respiratory Infection[1,3,4,5] n(%)	29 (13.9%)	63 (13.0%)
Impact of Respiratory Infection[1,5] (Mean±SD)	2.95±1.02	3.12±1.04
Other Infection[1,5] n(%)	27 (12.9%)	67 (13.9%)
Impact of other Infection[1] (Mean±SD)	3.04±1.25	2.85±1.27
Pressure Sores[1,2,4] n(%)	61 (30.8%)	137 (28.4%)
Impact of Pressure Sores[1,2] (Mean±SD)	2.78±1.34	3.01±1.30
Osteoporosis[1,2,3,5,] n(%)	54 (25.8%)	137 (28.4%)
Impact of Osteoporosis[1,2] (Mean±SD)	1.92±1.18	1.60±.1.16
Broken Bones/Dislocations[1] n(%)	22 (10.5%)	42 (8.7%)
Impact of Broken Bones/Dislocations[1] (Mean±SD)	3.38±1.39	3.13±1.33
Blood Clots/DVT[1] n(%)	5 (2.4%)	9 (1.9%)
Impact of Blood Clots/DVT[1] (Mean±SD)	2.41±1.67	2.33±1.69
Pain[1,2] (Mean±SD)**	5.83±2.16	5.43±2.20
SWLS[1,2,4] (Mean±SD)*	20.49±8.51	21.88±8.34
PHQ[1,2] (Mean±SD) **	5.30±4.47	4.06±4.39

n(%) = number and percent of individuals in each perceived overweight category who report a secondary complication (i.e. 66% of individuals who were overweight reported fatigue). The superscript notation represents the demographics characteristics included in the model:1= Controlling for age; 2=Controlling for YPI; 3=Controlling for sex; 4= Controlling for injury severity; 5=Controlling for mobility class

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

CHAPTER 6: GENERAL DISCUSSION

6.1 Summary of Key Findings

The overriding theme of this thesis was adiposity in individuals with SCI. The first manuscript confirmed that Total, Mobility, and Domestic ADL were not associated with adiposity (i.e. waist circumference) in individuals with SCI. However, Mobility ADL was negatively associated with LDL, and total cholesterol. The aerobic characteristics of Mobility ADL, and the frequency of wheeling and transferring as primary mobility activities may have contributed to these findings. Findings from Study 1 add to the growing body of literature that emphasizes the importance of certain types of daily activity. The study findings also suggest that participation in specific ADL, such as Mobility ADL may be beneficial in lowering CHD risk in individuals with SCI.

The second study examined the prevalence of secondary complications and reduced SWB among individuals who consider themselves to be overweight compared to those who did not consider themselves overweight. The brief validation prior to the analyses did support the use of the simple subjective overweight status measure. Not surprisingly, those who considered themselves overweight reported more pain, overuse injuries, and fatigue as well as greater depression and less satisfaction with life. This study was the first study to examine secondary complications and SWB and their relationship to measures of adiposity. Study findings also suggest that an objective measure of adiposity (specifically BMI) does not predict SWB or secondary complications in the SCI population.

6.2 Strengths of the Thesis

Both studies contained notable strengths. In Study 1, Generalized Linear Models (GLM) were used to predict the relationships between ADL participation and CHD risk. GLM are beneficial for analyses where data are not normally distributed and transformation of the data is not appropriate. Indeed, ADL data are almost always positively-skewed (i.e. the majority of individuals with SCI report minimal ADL participation while very few individuals report a large amount of ADL participation). Thus, transforming this variable would result in data that were not representative of ADL participation trends in the SCI population. Consequently the data were not transformed and thus using GLM were a more appropriate choice for analyses. In Study 2, the large sample size (N=695) adds to the generalizability of the study findings. In both studies, a large number of covariates were controlled for in the analyses including SCI specific characteristics such as mobility and injury severity. Controlling for these variables helps to strengthen study findings by removing cofounders from the analyses and increasing the likelihood that the established relationships are not due to extraneous factors.

6.3 Limitations of the Thesis

Despite the interesting findings, both studies were limited. For example, the sample size in Study 1 was small. It is possible that due to our small sample, we were unable to detect small effects between CHD risk and ADL participation. Furthermore, although negative relationships were found between some ADL and CHD risk factors, due to the cross-sectional nature of the data, we were unable to determine if these relationships were causal or clinically significant. Finally, although the PARA-SCI has been deemed reliable and valid, an objective measure of ADL may have yielded different results.

In Study 2, although the Secondary Complications Survey was partially validated, additional tests of validity and reliability are needed. Although our results are promising, further rigorous validation, particularly for the overweight measure should be conducted. Secondly, the small SHAPE-SCI subsample used in Study 2 to examine the relationships between objective adiposity, SWB and secondary complications may have contributed to the non-significant findings.

6.4 Future Research Directions

In Study 1 it would be interesting to examine if similar or different relationships emerge using an objective measure of ADL. For example, quantifying non-exercise activity thermogenesis using accelerometry may produce different relationships between Total ADL and adiposity. However, the use of a physical activity log such as the PARA-SCI also would still need to be used in order to differentiate between types of ADL (i.e. Mobility, Domestic). Using a larger sample would also be beneficial in determining if ADL participation is associated with any other CHD risk factors such as HDL or triglycerides. Finally, determining the clinical significance (i.e. Does Mobility ADL participation reduce the *occurrence* of CHD?) also would be beneficial in the promotion and prescription of these activities by healthcare professionals.

Study 2 is the first to examine adiposity, secondary complications, and SWB in individuals with SCI. Again, the use of cross-sectional data does not allow us to determine causality. Repeating the study using longitudinal data will allow researchers to determine if increases or decreases in adiposity are related to changes in secondary complications and SWB. Furthermore, using a larger sample to determine the relationships between objective measured adiposity and secondary complications in particular should be fully explored. Using dual-energy x-ray absorptiometry or another criterion measure of adiposity is advised.

6.5 Public Health Implications

The thesis findings support the notion of maintaining daily physical activity and a healthy bodyweight. Although future research is needed in order to determine causality, and influence practice guidelines, these preliminary findings will help build the foundation for future longitudinal studies.

The findings in Study 1 suggest that those individuals who are more active in their daily life, specifically participating in more Mobility ADL have lower CHD risk. The practical implications of Study 1 findings are that Mobility ADL participation should be promoted by practitioners in addition to LTPA in the SCI population. Notably, practitioners encouraging Mobility ADL participation should also remind clients of safe ADL practices in order to prevent injury.

The implications of Study 2 suggest that more adiposity may be related to a greater prevalence of certain secondary complications and poorer SWB. These cross-sectional findings hopefully lead to longitudinal studies that demonstrate that lowering adiposity through nutrition and physical activity interventions are successful at mitigating overuse injuries, pain, fatigue, depression, and improving satisfaction with life.

APPENDIX: CHAPTER 4 & 5 QUESTIONNAIRES

Screening and Demographic Information

Birth Date: ___________________ **Age:** ________ **Sex:** [M] [F]

Postal Code: __________________ **Date of SCI**: ______________________

Level of SCI: __________________ **Cause:** _________________________

Have you been told that you have a cognitive or memory impairment? ☐ Y ☐ N

Do you know your ASIA classification? _______________

If not, which of the following best describes you?

(A) No feeling or movement below the level of the injury. ☐
(B) Feeling all the way down to your rectum/bum but no use of muscles. ☐
(C) Limited movement or muscle contractions below level of the injury but these serve no useful function. ☐
(D) Functional, but not necessarily full use of at least half of the muscle groups below the level of the injury. ☐
(E) Feeling and movement is normal below level of injury ☐

What is your primary mode of mobility outside your home?

Manual Wheelchair ☐
Power Wheelchair ☐
Walker ☐
Braces ☐
Cane ☐
Walk Independently ☐

Which of the following describes your ethnicity?

☐ White ☐ Native Canadian ☐ Black ☐ Asian Other: ____________

What is the highest level of education you have completed?

☐ Highschool ☐ College ☐ University ☐ Post Graduate Other: ___________

What is your marital status?

☐ Single ☐ Common Law ☐ Married ☐ Divorced ☐ Widowed

Do you presently smoke? Yes ☐ No ☐

If yes, how many cigarettes do you smoke per day? __________

Do you drink alcoholic beverages? Yes ☐ No ☐

If yes, how many drinks per week? _____________

Patient Health Questionnaire (PHQ-9)

Over the last 2 weeks, how often have you been bothered by any of the following problems?

Little interest or pleasure in doing things
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Feeling down, depressed, or hopeless
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Trouble falling asleep, staying asleep, or sleeping too much
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Feeling tired or having little energy
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Poor appetite or overeating
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Feeling bad about yourself, feeling that you are a failure, or feeling that you have let yourself or your family down
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Trouble concentrating on things such as reading the newspaper or watching television
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Moving or speaking so slowly that other people could have noticed. Or being so fidgety or restless that you have been moving around a lot more than usual
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Thinking that you would be better off dead or that you want to hurt yourself in some way
0 Not at all
1 Several Days
2 More than half the days
3 Nearly every day

Pain Subscale from the SF-36

	None	Very Mild	Mild	Moderate	Severe	Very Severe
1. How much bodily pain have you had during the past week?						

	None	A Little Bit	Moderately	Quite a Bit	Extremely
2. During the past week, how much did pain interfere with your normal work (including both work outside the home and housework)?					

Satisfaction with Life Scale (SWLS)

Below are five statements that you may agree or disagree with. Using the 1 - 7 scale below, indicate your agreement with each item. Please be open and honest in your responding.

	Strongly Disagree 1	2	3	No Opinion 4	5	6	Strongly Agree 7
1. In most ways my life is close to my ideal.							
2. The conditions of my life are excellent							
3. I am satisfied with my life.							
4. So far I have gotten the important things I want in life.							
5. If I could live my life over, I would change almost nothing.							

Secondary Complications Survey (SCS)

	No	Yes	How much of an impact has this complication had on your daily life in the past 3 months?				
			None at All	Small Impact	Moderate Impact	Severe Impact	Very Severe Impact
Spasticity							
Overuse Injury (shoulder/elbow/wrist)							
Fatigue							
Urinary Tract Infection							
Respiratory Infection							
Other Infection							
Pressure Sores							
Pain							
Osteoporosis							
Broken Bones and/or Joint Dislocation							
Blood Clots, Deep Vein Thrombosis							
Overweight							
Other (Specify):________________ ________________							