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## Exploring The Relationship Between Locomotor Training And Bowel And Bladder Outcomes In Individuals With Spinal Cord Injury: A Scoping Review And Feasibility Study.

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## Abstract

This thesis explored the relationship between locomotor training and bowel and bladder function in individuals with Spinal Cord Injury (SCI). Study 1 was a scoping review that identified and summarized literature describing the relationship between locomotor training and bowel/ bladder outcomes in individuals with SCI and identified research gaps in the existing literature on bowel/bladder outcomes during locomotor training. Results of the scoping review suggested there is evidence of a positive relationship between locomotor training and bowel/bladder outcomes, however, most of that evidence was not collected using clinical outcome measures. Study 2 evaluated the feasibility of using clinical outcome measures, specifically the Spinal Cord Injury (SCI)-Quality of Life (QOL) v1.0 Bowel and Bladder Dysfunction Scales to assess bowel/bladder changes in people with SCI participating in inpatient or outpatient physical rehabilitation. Results suggested that the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were deemed mostly feasible to use by both inpatients and outpatients.

## Keywords

Spinal cord injury, bowel dysfunction, bladder dysfunction, locomotor training, feasibility

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## Abbreviation Index

6MWT 6 Minute Walk Test

10Q BFS 10-Question Bowel Function Survey

10MWT 10 Meter Walk Test

ANS- Autonomic Nervous System

AIS- ASIA Impairment Scale

ASIA- American Spinal Injury Association

BBS- Berg Balance Scale

BE- Bowel Evacuation

BEfreq- Bowel Evacuation Frequency

BEtime- Bowel Evacuation Time

BSS- Bristol Stool Scale

CI- Confidence Interval

CIC- Clean Intermittent Catheterization

C-SWAT- Canadian SCI Standing and Walking Assessment Tool (as part of the Canadian Standing and Walking Measures Toolkit of the Rick Hansen Spinal cord Injury Registry)

DGI- Dynamic Gait Index

FIM- Functional Independence Measure

GI- Gastro-intestinal

IP- Inpatient

IRT- Item Response Theory

ISNCSCI- International Standards for Neurological Classification of Spinal Cord Injury

LMN- Lower Motor Neuron

LT- Locomotor Training

MDC- Minimal Detectable Change

MVC- Motor Vehicle Crash

N/A- Not Applicable

OP- Outpatient

PAL- Parkinson's Active Living

PRO- Patient-Reported Outcome

QOL- Quality of Life

REB- Research Ethics Board

SC- Stool Consistency

SCI- Spinal Cord Injury

SCI-FAI- Spinal Cord Injury Functional Ambulation Inventory

SCIM- Spinal Cord Independence Measure

UMN- Upper Motor Neuron

UTI- Urinary Tract Infection

TUG- Timed Up and Go

# 1 Literature Review

## 1.1 Background

A Spinal Cord Injury (SCI) involves any damage to the spinal cord that results in permanent or temporary changes in sensory, motor, and autonomic function (Kirshblum et al., 2011). Damage to the spinal cord can occur traumatically, where an external force acts upon the spine (e.g., hyperextension or compression from falls), or non-traumatically, without the presence of an external force (e.g., spina bifida, arthritic changes leading to regional myelopathy, degeneration of the spinal cord, tumors or bone metastases; New & Delafosse, 2012).

## 1.2 SCI Epidemiology, Cause, and Classification

In 2012, there were an estimated 85,556 persons living with SCI in Canada (51% traumatic SCI, 49% non-traumatic SCI; Noonan et al., 2012). In North America, the incidence of traumatic SCI is between 17 to 83 individuals per million (Furlan et al., 2014). The global incidence rate of SCI is rising, which may be due to an increase in overall human activity (e.g., increase of motor vehicles on roads; (Kang et al., 2017). Globally, males outnumber females among individuals with traumatic SCI. In developed countries the ratio can be as high as 10:1 (Kang et al., 2017).

Motor vehicle crashes (MVCs) remain the most common cause of traumatic SCI (in both Canada and globally), accounting for 41% to 45% of all SCIs (Kang et al., 2017). The second-most common cause of traumatic SCI is falls (and the primary cause for individuals 45 and older), accounting for 24.5% to 27.3% of SCIs in the United States (Furlan et al., 2014). This trend carries across both developed and non-developed countries (Kang et al., 2017). As the risk for falls increases with age, it is anticipated that falls will continue to be a major cause of SCI given a global aging population (Rubenstein, 2006). An increase of non-traumatic SCI as a result of spinal cord age-related degeneration is also expected (Noonan et al., 2012). Unfortunately, little data is

available on the incidence rate of non-traumatic SCI in Canada or anywhere else (Noonan et al., 2012).

### 1.2.1 SCI Classification

The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) is the internationally accepted standard for assessing and documenting the neurological status of someone with a traumatic SCI. The ISNCSCI includes a motor exam (strength assessment of 10 key muscles), and sensory exam (light touch and pin prick testing of key points) to determine neurological level of injury; and evidence of motor or sensory sparing below the level of injury to determine severity and assign an American Spinal Injury Association (AIS) classification (A=complete injury, B= sensory incomplete, C, D= motor incomplete, E=normal). An SCI is assessed as complete (AIS A) if there is no evidence of sensory or motor function in the sacral segments, based on manual testing of deep anal pressure and voluntary contraction of the anal sphincter (Kirshblum et al., 2011). Any voluntary contraction (i.e., bearing down against the finger) or sensation signifies an incomplete injury. (Kirshblum et al., 2011). In the case of a sensory incomplete classification, some sensory but not motor function will be preserved below the neurological level, including S4-S5. Motor incomplete classification would entail partial motor function preservation below the neurological level, with more than half of key muscles having a muscle grade of less than 3. Finally, if all motor and sensory function is normal, a classification of E will be received (Kirshblum et al., 2011).

In addition to the ISNCSCI, the Canadian SCI Standing and Walking Assessment Tool (c-SWAT) can be used to classify SCI. The c-SWAT is a functional assessment that evaluates the individual's ability to perform specific tasks (capacity for standing and walking) and not their neurological level of injury (Craven et al., 2012). The c-SWAT is an important assessment tool as it reflects a progression in their standing and walking skills, helps set realistic goals, and provides guidance for forming customized physical therapy protocols (Craven et al., 2012). The c-SWAT grades range from 0 to 4 (0= non-independent sitting—4- full walking capacity).

## 1.2.2 Ambulation and Locomotor Training Following SCI

Recovery of walking function is often a top priority for individuals following SCI (Nooijen, Ter Hoeve, & Field-Fote, 2009). Locomotor training (LT) is a rehabilitation strategy that aims to improve postural control, standing, and walking following SCI. Various modalities may be employed to engage clients in LT: hands-on facilitation/handling by therapists with or without additional use of gait aids, such as platform walkers; robotic exoskeletons on treadmills or over ground; or bodyweight support harnesses to support upright trunk and pelvis positioning while walking on treadmills or over ground (Harkema et al., 2012). Each approach uses active or passive activation of the neuromuscular system through repetitive functional tasks to promote functional reorganization of the neuromuscular system and “relearning” of walking patterns (Harkema et al., 2012). Improvements in ambulation have been strongly correlated with improved quality of life (QOL; Sharif et al., 2014). This may be due to increases in independence and overall mobility, as physical function (including ambulation) as well as independence (a sub-domain of social participation) are both components of QOL for individuals with SCI as described by Tulskey and colleagues (2015; Sharif et al., 2014; Tulskey et al., 2015).

## 1.3 Bowel and Bladder Dysfunction - Impact, and Measurement after SCI

### 1.3.1 Bowel and Bladder Dysfunction

Bowel and bladder dysfunction are prevalent in individuals with SCI. More than 98% of individuals with SCI residing in the community experience at least one bowel problem related to their SCI (i.e., constipation, incontinence, prolonged evacuation time: Burns et al., 2015). Bladder dysfunction is also prevalent, with up to 95% of individuals experiencing it after an SCI (Burns et al., 2015). Some problems associated with bladder dysfunction include incontinence and urinary tract infections (UTIs; Cameron et al., 2015).

### 1.3.2 Neuroanatomy of Bowel and Bladder Dysfunction

Bowel and bladder control is provided by the sacral portion of the spinal cord, specifically S2-S4, and is also regulated by the autonomic nervous system (Krassioukov, 2009). The autonomic nervous system (ANS) is comprised of two components: sympathetic and parasympathetic (Krassioukov, 2009). The sympathetic and parasympathetic components work together within the central nervous system (CNS) to regulate the heart, bronchial pulmonary tree, as well as the bladder, reproductive organs, and the lower part of the intestines or colon (Krassioukov, 2009). Although SCI can have drastic effects on mobility, it can also result in marked autonomic deficits (Taylor 2018). Autonomic deficits are generally more severe in individuals with a high neurological level of injury (T6 and above), and in those without sensory or motor function in the sacral segments S4-5 (i.e., a complete SCI: Hou & Rabchevsky, 2014). For example, cardiac dysfunction, such as bradycardia is usually present in individuals with high thoracic or cervical injuries and not in individuals with lumbar injuries (Hou & Rabchevsky, 2014).

Due to the disruption in the autonomic control of the gastrointestinal (GI) tract following SCI, symptoms such as prolonged bowel transit time, constipation, and bowel incontinence can be experienced. There are two distinct clinical presentations of bowel dysfunction: injury above the conus medullaris typically results in upper motor neuron (UMN) bowel syndrome, characterized by increased colonic wall and anal tone. This type of bowel dysfunction is associated with constipation, and fecal retention (Singal et al., 2006). Injuries below the conus medullaris result in a lower motor neuron (LMN) bowel syndrome, characterized by slow fecal propulsion and impaired stool evacuation (Stiens, Bergman, & Goetz, 1997). This type of bowel dysfunction is associated with constipation and a high risk of incontinence (Stiens et al., 1997).

Similarly, bladder dysfunction is also a product of disruption in the connectivity in the sacral region. Individuals with UMN injuries are most likely to present with external sphincter dyssnergia or hyperflexic bladder, characterized by overactive, spastic, or reflexive detrusor muscle activity (Minassian et al., 2016). Individuals with LMN injuries



are more likely to present with the detrusor areflexia or flaccid bladder, characterised by underactive detrusor muscle activity (Minassian et al., 2016).

Krassioukov and colleagues (2012) suggested that there are a number of ways to evaluate remaining autonomic function for bowel and bladder function following SCI (Krassioukov et al., 2012). Krassioukov et al., 2012 outlined a method to evaluate remaining autonomic bowel and bladder control, to be used in conjunction with the ISNCSCI: a self-reported measurement that assigns a score of 2 for uninterrupted bowel/bladder function and 1 for altered or reduced control, and 0 for absent control (Krassioukov et al., 2012). The authors recognized that aside from urodynamics, there are no direct tests that evaluate bladder, distal bowel, and sexual function. The authors recommend using patient-reported outcomes in conjunction with the ISNCSCI, which evaluates sensory and motor function of the sacral segments through manual testing of deep anal pressure and the presence or absence of voluntary contraction of the anal sphincter (Kirshblum et al., 2011).

### 1.3.3 Impact on Quality of Life

Both bowel and bladder dysfunction can have a significant impact on an individual's QOL by limiting one's ability to participate in physical activity, social engagement, and negatively impacting self-esteem (Burns et al., 2015). Bowel and bladder programs are individual approaches designed to aid in managing one's bowel and bladder. Components of a bowel program may include laxatives or suppositories in combination with manual evacuation performed independently or with assistance from a family member or nurse. Intermittent catheterization or an indwelling catheter can be used for bladder management (Jamil, 2001). For catheter-free management, patients may use the Crede maneuver (i.e., use of manual pressure on the bladder), or the Valsalva maneuver (i.e., moderately forceful exhalation through a closed airway) to empty their bladders. Bladder contraction may be triggered by supra-pubic tapping for people who have bladders that exhibit weak uninhibited contractions (Jamil, 2001). However, even when performed correctly, programs can take a long time to complete (especially bowel programs that may take up to two hours to complete; Hsieh et al., 2014). In addition, programs may not be 100% effective (Hsieh et al., 2014). Catheter-free management of bladder dysfunction,

specifically the use of Crede and Valsalva manoeuvres may worsen hernias and hemorrhoids due to increase in pressure (Jamil, 2001). Incomplete voiding may occur when using catheter-free management and may lead to an increased risk for UTIs (Böthig et al., 2012).

### 1.3.4 Measurement

Bowel and bladder function can be assessed using both objective and subjective measures. Objective measures may include measures that record changes in consistency and frequency of evacuation, reliance on medication (e.g., laxatives, suppositories), urine volume, and frequency of urinary tract infections (Hsieh et al., 2014). One of the most common ways to evaluate bowel dysfunction is by administering the Neurogenic Bowel Dysfunction Form (see Appendix 6). The tool is comprised of objective questions focusing on frequency and duration of evacuation and use of medication. Due to the scope of this work, this thesis will not be addressing clinical approaches to measuring bowel and bladder dysfunction.

Subjective measures such as patient reported outcomes (PROs) may also be used to assess bowel and bladder function by evaluating the impact of bowel and bladder function on participants' QOL. PROs measure the patient's perceived impact of a condition or intervention, therefore highlighting the participant's needs and expectations for quality of life (Tulsky et al., 2011). Recently, PROs have become an essential part of any clinical trial (Tulsky et al., 2011). PROs have also been proven to be more cost-effective and less labor intensive during data collection than physiological measures (Nixon, Spackman, Clement, Verma, & Manns, 2018).

One PRO that can be used to assess bowel and bladder dysfunction is the Spinal Cord Injury-Quality of Life (SCI-QOL) Bowel and Bladder Dysfunction Scales (see Appendices 1-3) developed by Tulsky et al., 2015. This instrument has been shown to be reliable and valid for assessing the impact of bowel and bladder management difficulties on QOL in individuals with SCI (Tulsky et al., 2015). Seven hundred and fifty-seven individuals with SCI were consulted and participated in the development of the item pool that was collapsed into the three sub-scales that comprise the SCI-QOLv1.0 Bowel and

Bladder Dysfunction Scales (Tulsky et al., 2015). To assess test-retest reliability, a second sample of community-dwelling adults with traumatic SCI was recruited. Participants in the development process were predominantly male (79.1%), more than three years post-injury (43.5%) and community-dwelling. Incomplete tetraplegia was the most common condition (34.4%), followed by complete paraplegia (23.9%; Tulsky et al., 2015). Although the participants involved during testing were representative of the general population living with SCI, the scales were not tested with individuals acutely post-injury or in the early phases of rehabilitation. These individuals may have different concerns and management difficulties from their community-dwelling counterparts.

## 1.4 Locomotor Training Effects on Bowel and Bladder Dysfunction

Recently, studies examining secondary benefits of locomotor training such as pain and spasticity have emerged. So far, there is evidence of improved pain and spasticity following locomotor training (LT) using exoskeleton robots over ground (i.e., Ekso) and over treadmill (Lokomat), and bodyweight support treadmill (Hou et al., 2014; Manella & Field-Fote, 2013; Mirbagheri et al., 2011). Bowel and bladder function improvement may be another secondary benefit of LT, especially given that in the able-bodied population, walking and running have been associated with reduced constipation (Zamany & Teymouri 2013; Dukas et al., 2003) and reduced bowel transit time.

A recent study by Hubscher et al., 2018 reported an increase in bladder volume, as well as an increase in voiding efficiency in individuals with SCI following 80 daily one-hour sessions of LT on a treadmill using body-weight support (or one-hour of LT and stand training on alternate days; Herrity et al., 2016). A similar study by Morrison and colleagues (2018) reported that participants experienced an increase in bowel movement sensation following 60 LT sessions on a body-weight support treadmill system (Morrison et al., 2018). Although additional evidence for the positive relationship between bowel and bladder function and LT exists, this evidence is anecdotal (i.e., participants reported improved bowel or bladder function to the researcher even when bowel and bladder were not a measured outcome in the study). Hence, future research should aim to

systematically record bowel and bladder changes with LT intervention. One way to record bowel and bladder function changes following LT is using PROs.

The SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were developed with predominantly males living with incomplete, traumatic SCI in the community to reflect the needs and concerns of the majority of, but not all individuals living with SCI. Therefore, a feasibility assessment of these PROs is necessary to determine whether these measures are acceptable or appropriate for individuals who are more acute post-injury or in the early phases of rehabilitation. Given the existing time and resources available within an inpatient/outpatient rehabilitation facility these measures should also be assessed for ease of implementation and practicality. Finally, the limited efficacy of these measures and the possible limitations for use in a larger scale study should also be assessed.

## 1.5 Assessing Feasibility

To determine whether a full trial will be successful, a pilot study can be conducted (Thabane et al., 2010). Pilot studies are a way to enhance the likelihood of success for large, controlled trials. An article by Thabane and colleagues (2010) outlines reasons for conducting pilot studies (e.g., process, resources, management, scientific) and addressed key frequently asked questions (i.e., can the results of a pilot study be published?). The article suggests that pilot studies are a cost efficient and low risk opportunity to prepare for a large-scale trial (Thabane et al., 2010). Feasibility studies are another way to test an intervention or instrument on a small scale before completing efficacy testing (Bowen et al., 2009). Similar to pilot studies, feasibility studies can be conducted to avoid “research waste” (e.g., time and/or resources; Morgan, Hejdenberg, Hinrichs-Krapels, & Armstrong, 2018) by reducing the risk that resources will be allocated towards a trial that may “fail” (e.g., not be carried out to completion or proven to be too strenuous on existing resources; Morgan et al., 2018). Given that many interventions and instruments are developed in highly controlled settings, feasibility studies also allow researchers to observe if the interventions/instruments can be generalized to a real-world/clinical setting, or to different populations.

Bowen and colleagues (2009) described a detailed feasibility framework. This framework is widely used in a variety of healthcare fields. Unlike the framework in Thabane et al. 2010, this framework focuses not only on scaling down an intervention (e.g., smaller number of participants, shorter intervention time, etc.), but also on the mechanisms by which it is administered. The framework identifies eight areas of focus that can be addressed by feasibility studies: acceptability, demand, implementation, practicality, adaptation, integration, expansion, and limited-efficacy testing. For the purpose of this thesis, the following four areas were deemed appropriate for investigation:

- Acceptability
- Implementation
- Practicality
- Limited-efficacy

### 1.5.1 Acceptability

The area of acceptability focuses on the intended population for the intervention and their reactions to the intervention or instrument. Questions from this area can focus on satisfaction with the intervention, the intent to continue using the intervention, and the perceived appropriateness by the intended population (Bowen et al., 2009). The area of acceptability selected for investigation was the appropriateness of the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales in an inpatient population. As an example, Boone and colleagues (2017) evaluated the perceived acceptability of a new combined motor and cognitive strategy training intervention for stroke. Acceptability was tested through measuring the extent to which the intervention was congruent with the needs and interests of the target population (Boone, Morgan, & Engsberg, 2017). The results of the study suggest that the new combined motor and cognitive strategy was viewed as innovative and important by both patients and therapists, suggesting that this intervention can be used with the intended population.

### 1.5.2 Implementation

The area of implementation concerns the extent, likelihood and way the intervention can be fully implemented as planned (Bowen et al., 2009). Questions from this area can focus

on the degree of execution and the success or failure of the execution. The area of implementation was selected for investigation to test whether sufficient resources (e.g., time, assistance) were provided to the participants for the completion of the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales. For example, in a study by Butterfield et al., 2016 implementation was measured in the context of using the Parkinson's Active Living (PAL) Program to target apathy in individuals living with Parkinson's disease. Implementation was assessed based on the percent of adherence to the program in newly trained interventionists (Butterfield et al., 2017). Given the low cost and ease of implementation, the authors concluded that the PAL Program can be easily integrated into weekly psychotherapy sessions or support groups.

### 1.5.3 Practicality

The area of practicality assesses to what extent the intervention can be carried out if the resources such as time or commitment by researcher or participant is constrained. This area can include a cost analysis or questions about the positive/negative effects on the targeted population (Bowen et al., 2009). The area of practicality was selected for investigation to test whether the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were administered at the right time, were easy to complete and could be administered with limited assistance from support staff and/or researcher. In a study by Nixon et al., 2017 concerning the feasibility of using person-centered self-management education approaches for hard to reach people with chronic illnesses, practicality was evaluated through two themes imbedded in semi-structured interviews. The two themes targeted issues related to time and educator competencies (Nixon et al., 2018). Time was identified as a potential barrier to successful implementation of person-centered self-management education by educators.

### 1.5.4 Limited efficacy

The area of limited efficacy assesses whether the intervention can be impactful even in a highly controlled setting with a small sample size (Bowen et al., 2009). This area may include a sample size calculation and an effect size estimation. The area of limited-efficacy was selected for investigation to provide preliminary information about the SCI-

QOLv1.0 Bowel and Bladder Dysfunction Scales that could inform a full-scale trial. In a study by Donkers et al., 2017, limited efficacy was evaluated through interviews. The study focused on the feasibility of using the Social Fitness Program for social participation in individuals with cognitive problems, and their caregivers. Questions about meaningful change were asked of the participants and caregivers in a semi-structured interview format (Donkers et al., 2017). Results revealed that most caregivers felt disappointed in the program's results and expected a greater change, however, seemed to have accepted the situation. The authors concluded that following the modification of the intervention to better meet the needs of caregivers and additional training of professionals, a consecutive pilot study to assess feasibility is justified (Donkers et al., 2017).

## 1.6 Summary

Bowel and bladder dysfunction is experienced by nearly all individuals with SCI (Burns et al., 2015) and has a significant impact on QOL (Burns et al., 2015). Bowel and bladder programs are implemented to manage bowel and bladder dysfunction, however, even when conducted correctly, programs may not be 100% effective. Issues with bowel/bladder programs and bowel/bladder dysfunction can lead to incontinence, constipation, and secondary health complications such as hemorrhoids, hernias, UTIs, and kidney stones. Symptoms of bowel and bladder dysfunction and secondary health complications may lead to a significant reduction in QOL through limited time to participate in physical, leisure, and social activity, and increased time allocated to bowel and bladder programs. Recent findings suggested that there may be a positive relationship between bowel and bladder function and locomotor training (Herrity et al., 2016; Morrison et al., 2018). Therefore, to address the gaps within the literature a scoping review would be able to identify and summarize the existing literature that described a relationship between locomotor training and bowel/ bladder outcomes in individuals with SCI following LT.

One way to systematically record bowel and bladder changes following LT is through PROs. The SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales are PROs developed with high involvement of the SCI community to address difficulties and complications

associated with bowel and bladder dysfunction (Tulsky et al., 2015). However, these scales may not generalize to individuals with SCI who are still in acute and inpatient rehabilitation settings, as these individuals may experience different concerns from their community-dwelling counterparts. Therefore, there is a need to address the issues of feasibility of administering the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales to individuals with SCI participating in both inpatient and outpatient rehabilitation programming.

## 1.7 Objectives

1. To examine the extent, range, and nature of research on bowel/bladder outcomes during locomotor training in individuals with SCI, summarize research findings, and to identify research gaps in existing literature on bowel/bladder outcomes during locomotor training.
2. To test the feasibility of using SCI- QOL v1.0 Bowel and Bladder Dysfunction Scales to assess bowel and bladder dysfunction in individuals with SCI participating in inpatient or outpatient rehabilitation programming.



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## 2 Bowel and Bladder Outcomes Following Locomotor Therapy in Individuals with Spinal Cord Injury (SCI): A Scoping Review

### 2.1 Introduction

Bladder and bowel dysfunction as a direct result of spinal cord injury (SCI) is experienced in 98% of all cases (Burns et al., 2015; Cameron et al., 2015). Although regaining ambulation is often a significant goal shortly following an SCI, priorities shift to the prevention and management of secondary health complications in the years to come, including the management of bladder and bowel dysfunction. For those experiencing bladder dysfunction, frequent urinary tract infections (UTIs), kidney stones, or renal failure can lead to a significant decrease in quality of life (QOL; Leduc, Spacek, & Lepage, 2002). Likewise, bowel dysfunction is also highly correlated with QOL (Burns et al., 2015). Some secondary complications that may occur due to bowel dysfunction are constipation and hemorrhoids (Burns et al., 2015). Bladder and bowel function are a high priority for individuals living with SCI, as identified in a review by Simpson and colleagues (2014), where bladder and bowel function were consistently ranked among the top four health concerns (Simpson et al., 2012).

Neurogenic bowel and bladder are conditions that occur due to disrupted autonomic control of the gastrointestinal (GI) tract (Krassioukov, 2009). There are two types of neurogenic bladder or bowel dysfunction: hyper-reflexic bladder/bowel occurs with injuries at T12 and higher, and areflexic or flaccid bladder/bowel with injuries at L1 and lower (Krassioukov et al., 2011). These changes can lead to difficulties voiding, prolonged bowel transit time, incontinence, and over the lifespan can contribute to more serious health complications, such as hemorrhoids or constipation. Poor diet and limited mobility can exacerbate these symptoms (Krassioukov, 2009).

One of the most common neurogenic bowel complications is constipation (Burns et al., 2015). Difficulties in voiding the bowels can lead to straining and prolonged bowel routines, which in turn can cause damage to the skin around the inside and outside of the rectum. There are numerous ways in which symptoms of bowel and bladder dysfunction

can be managed. Typically, neurogenic bowel dysfunction complications (e.g., constipation and incontinence) is managed with a combination of medication, diet modifications, and digital evacuation. Surgical interventions, such as colostomies, are infrequent and are only used as a last resort (Burns et al., 2015). However, even a successful and well-managed bowel routine can sometimes take up to two hours to complete and individuals may need to rely on a personal support worker, nurse, or family member to complete the routine. Therefore, bowel routines even when carried out correctly and without complications, can significantly reduce quality life by diverting time from other activities and increasing dependency on others. Inability to control bowel and bladder function can make it difficult for individuals to leave their house for extended periods of time, negatively impact social life, or make it difficult to engage in physical activity (Adriaansen et al., 2016). Bladder dysfunction can also be managed with medication, catheterization or an indwelling catheter. However, incontinence may still occur and interrupt daily activities.

Locomotor training (LT) is a rehabilitation strategy for the improvement of postural control, standing, and walking function following SCI to optimize independent ambulation (Harkema et al., 2012). Different modalities of LT are available to individuals with SCI, including robotic exoskeletons for over ground (e.g., Ekso) or treadmill walking (Lokomat) and bodyweight support treadmill training (Field-Fote, Lindley, & Sherman, 2005). However, the secondary health benefits of locomotor training have only recently been a topic of interest. Exercises such as walking or running have shown potential for reducing bowel transit time and alleviating symptoms of constipation in people without SCI or other injury or disease (Dainese et al., 2004; De Schryver et al., 2005). SCI animal models have also begun to emerge that aim at better understanding the relationship between locomotor training and bladder and bowel function. In these studies locomotor training has been shown to improve bowel and bladder function in rats (Hubscher et al., 2016a). However, very little literature exists concerning a human population with SCI and locomotor training, and its potential impact on bladder and bowel function. The purpose of this scoping review was to identify and summarize literature that described a relationship between locomotor training and bowel/ bladder outcomes in individuals with SCI.



## 2.2 Methods

This study was guided by the five stages for scoping reviews, described by Arksey & O'Malley (2005):

Stage 1: Identifying the research question

Stage 2: Identifying relevant studies

Stage 3: Study selection

Stage 4: Charting the data

Stage 5: Collating, summarizing and reporting the results

### 2.2.1 Identifying the Research Question

The research question was arrived at by consulting with multiple stakeholders, over several meetings. This direction was initiated and informed by input from several clinicians reflecting on feedback they received from their patients. Anecdotal evidence provided by the physiotherapists and occupational therapists working on the inpatient and outpatient SCI programs at Parkwood Institute, London, ON, suggested a positive relationship between locomotor training and outcomes associated with bowel/bladder function, which prompted this literature search.

The purposes of this scoping review:

- (1) To examine the extent, range, and nature of research on bowel/bladder outcomes during locomotor training in individuals with SCI.
- (2) To summarize research findings.
- (3) To identify gaps in existing literature on bowel/bladder outcomes during locomotor training.

### 2.2.2 Identifying Relevant Studies

Six electronic databases were searched from inception to June 2018: Embase (1947 - June 2018), Nursing and Allied Health Database (1857- June 2018), PubMed (1820-June

2018), Scopus (1966-June 2018), Web of Science (1900 - June 2018), and CINAHL (1937- June 2018). The search strategy used was created in consultation with a university librarian who specializes in academic literature searches. The following search strategy was used to search headings and keywords in each database in addition to the related terms summarized in Table 1: {"spinal cord injury" AND "locomotor therapy" AND ("bowel function" OR "bladder function")}.

Table 1

*Summary Table of Search Terms Used During Literature Search*

<u>Key word</u>	<u>Related Terms</u>
Spinal cord injury	Paraplegia, tetraplegia, quadriplegia, spinal cord damage.
Locomotor training	Lokomat, Ekso, ReWalk, Bodyweight support
Bowel function	Neurogenic bowel, bowel outcomes, bowel, bowel incontinence, voiding, constipation
Bladder function	Bladder, neurogenic bladder, bladder incontinence, bladder outcomes

### 2.2.3 Study Selection

The inclusion criteria for studies was as follows: (1) study participants to be comprised of only people living with traumatic and non-traumatic SCI, (2) study intervention described

as locomotor training (3) study described bowel/ bladder outcomes following locomotor training. Published conference abstracts were deemed eligible, as they increased breadth of review and provided assurance that the most recent literature was included. Titles and abstracts were reviewed by AR and DW to determine appropriateness for full-text review. Conflicts were discussed and resolved by a third reviewer (LG). Full text-review was conducted by AR. Only electronic sources (e.g., academic journals available online) were consulted during the search, however, reference lists of selected articles were also searched to identify additional relevant studies by AR.

#### 2.2.4 Charting the Data

For each study selected, the following data were extracted and tabulated: country of origin, study design, sample size and description (gender, age, time post-injury, neurological level of injury and severity, where available), equipment used (e.g., exoskeleton, bodyweight support treadmill); frequency, intensity, and duration of locomotor training; and main findings (locomotor and bowel/bladder changes).

#### 2.2.5 Collating, Summarizing, and Reporting Results

Data extracted from each study were reviewed for similarities and differences in sample (e.g., time since injury, level of injury), intervention, and main findings to identify gaps and opportunities for future study.

### 2.3 Results

Eleven articles were considered eligible and included in this review. Figure 1 illustrates the number of articles obtained in each step of the selection process. The initial database search yielded 405 possible studies. There was 100% agreement for inclusion in the full-text review.

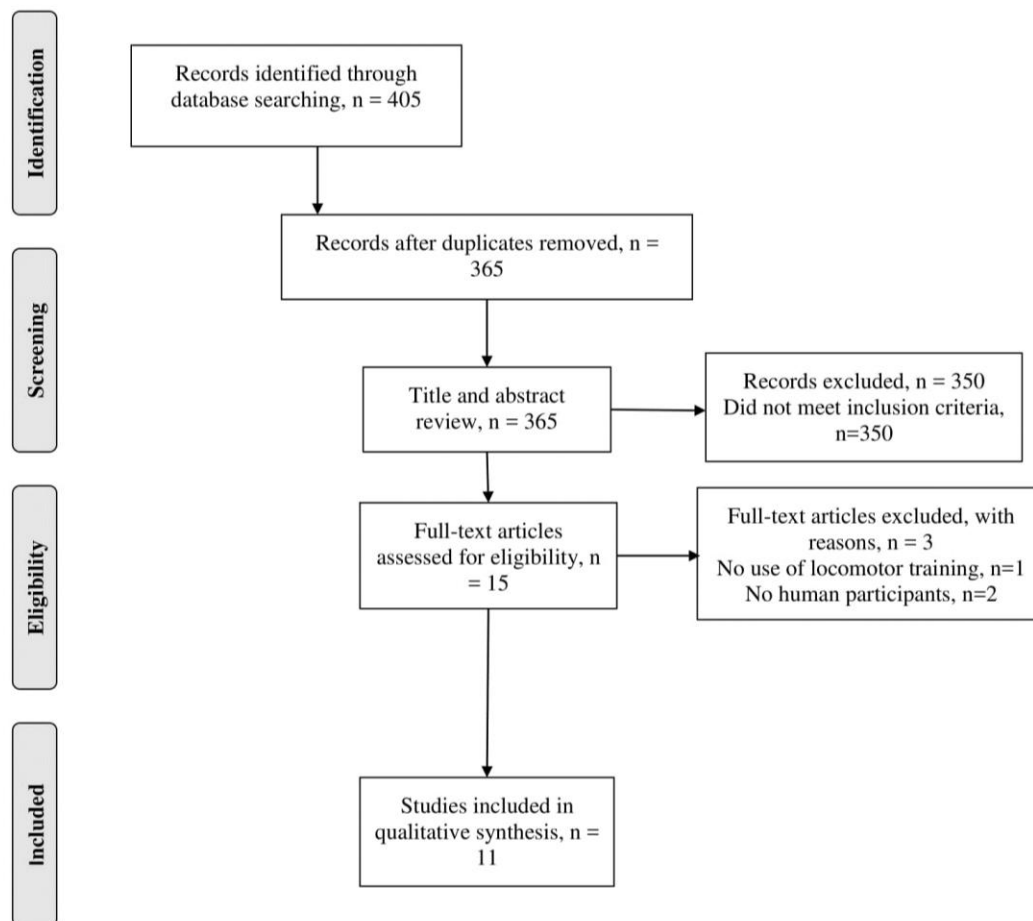


Figure 1 Flow-diagram of article inclusion process.

### 2.3.1 Study Designs and Sample Characteristics

Of the 11 studies selected for data abstraction, one was a meta-analysis (Miller, Zimmermann, & Herbert, 2016a), three were conference abstracts (Black-Bain, 2014; Fineberg et al., 2013; Herrity et al., 2016a) and seven were independent studies published in peer-reviewed journals (Di Vico et al., 2017; Esquenazi et al., 2012; Hubscher et al., 2018; Kozlowski, Bryce, & Dijkers, 2015; Morrison et al., 2018; Raab et al., 2016; Spungen et al., 2014). Two of the seven independent studies were case studies (Black-Bain, 2014; Raab et al., 2016). The meta-analysis was included to increase the breadth of the scoping review. The authors recognize that the meta-analysis did contain articles already identified for qualitative synthesis (Esquinazi et al., 2012; Kozlowski, Bryce, & Dijkers, 2015). Articles from the meta-analysis were only included if they were

identified through the original electronic search. Given that the purpose of the scoping review was to identify and analyze any available literature describing bowel/bladder function and locomotor training, excluding the meta-analysis would have significantly limited the literature available on the topic.

Conference abstracts were included in this scoping review but provided limited information about the methodology and participants of the study. Overall, the participants in the included studies were largely heterogeneous, with diagnoses varying from AIS A to AIS C, and varying levels of injury. Excluding the meta-analysis by Miller and colleagues (2016), the greatest number of participants recruited was 69 and, two studies were single case studies. For study design and participant characteristics see Table 2

Table 2

*Study Design and Sample Characteristics of Articles Included in the Scoping Review*

<u>Authors</u>	<u>Country</u>	<u>Study Design</u>	<u>N</u>	<u>Sample (Gender; Age; Time Post-Injury; Level of SCI; Severity)</u>
Miller et al., 2016	USA	Review with meta-analysis	111	Predominantly male; 27- 46 years old; ; C4- L1; ;
Raab et al., 2016	Germany	Single case study	1	Male; 22; ; T11; AIS C
Esquenazi et al., 2012	USA	Open, noncomparative, nonrandomized study	12	4 Female, 8 Male; ; T3 – T12; ;
Kozlowski et al., 2015	USA	Longitudinal cohort design with a convenience sample, pre/post evaluation	7	7 Male; 2 tetraplegia, 5 paraplegia; ; ; 5 motor complete

Herrity et al., 2016	USA	Controlled study, pre/post evaluation	8	Not provided
Fineberg et al., 2013	USA	Controlled study, pre/post evaluation	4	;;;;; Motor complete
Black-Bain, 2014	USA	Single case study	1	Female; ; ; T10, AIS C
Spungen et al., 2014	USA	Controlled study, pre/post evaluation	8	;;;;; T1-T-11
Hubscher et al., 2018	USA	Controlled study, pre/post evaluation	8	;;;;; C4-T5, AIS A-C,
Morrison et al., 2018	USA	Prospective observational cohort with longitudinal follow-up	69	20 Female, 49 male; ; 0.1-45y post injury; ; ;
Di Vico et al., 2017	Italy	Controlled study, pre/post evaluation	30	;;;;; 15 complete and 15 incomplete; ;

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*Note.* USA (United States of America); AIS (ASIA Impairment Scale) - American Spinal Injury Association (ASIA) classification ranges from A to E (A=complete injury; B=sensory incomplete; C, D= motor incomplete; E=normal; Kirshblum et al., 2011). Spaces between semicolons (; ;) signify data that was sought after as indicated in column headings but was not available.



### 2.3.1.1 Locomotor Training Protocols

Eight of 11 studies, including the meta-analysis by Miller and colleagues (2016) used an exoskeleton for locomotor training. The remainder of the studies utilized bodyweight-support treadmill walking, cycling, or standing frame as part of the intervention. The primary goal of three studies was locomotor training, specifically, the goal was to improve locomotor outcomes (e.g., walking distance, walking speed), or to assess elements of locomotor function (e.g., balance, step length/width). Locomotor training duration varied across the studies from 30 minutes (Kozlowski et al., 2015) to 120 minutes (Fineberg et al., 2013). Frequency of locomotor training also varied greatly from 2-3 times a week (Fineberg et al., 2016; Kozlowski et al., 2015; Raab et al., 2016) for as little as 6 weeks (Black-Bain, 2014) to daily sessions for up to 80 consecutive days (Hubscher et al., 2018).

### 2.3.1.2 Outcome Measures

#### 2.3.1.2.1 Locomotor Outcomes

Six studies reported locomotor outcomes, specifically 10 Meter Walk Test (10 MWT), 6 Minute Walk Test (6 MWT), Berg Balance Scale (BBS), and overall walking distance, and walking speed (Black-Bain, 2014; Esquenazi et al., 2012; Hubscher et al., 2016; Miller, Zimmermann, & Herbert, 2016; Morrison et al., 2018; Raab et al., 2016). In all six studies, participants increased their BBS score, decreased their time on the 10 MWT, increased their distance on the 6MWT, and improved overall on walking distance and speed.

#### 2.3.1.2.2 Bowel and Bladder Outcomes

In six studies bowel and bladder improvements following LT were the primary outcomes (Di Vico et al., 2017; Fineberg et al., 2016; Herrity et al., 2016; Hubscher et al., 2018; Morrison et al., 2018; Spungen et al., 2014). Four studies reported improvements in bladder function and five studies reported bowel improvements, some studies reported on both bowel and bladder function outcomes. Bladder improvements were characterized as

increased bladder capacity and increased urinary continence (Herrity et al., 2016) . Bladder capacity was assessed through urodynamic assessments and filling cystometry.

Bowel improvements were characterized as reduced evacuation time, better stool consistency, and a decrease in reliance on laxatives/stool softeners (Esquenazi et al., 2012; Raab et al., 2015; Hubscher et al., 2018; Morrison et al., 2018). In two studies bowel/bladder improvements were reported through a self-report questionnaire (i.e., 10Q BFS, SCI-QOL; Hubscher et al., 2018; Spungen et al., 2014). Four studies reported bowel/bladder outcomes anecdotally (Black-Bain, 2014; Esquinazi et al., 2016; Kozlowski et al., 2015; Raab et al., 2016). Anecdotal reports were provided by participants to the researcher without the use of any systematic format (e.g., questionnaire). Two studies discussed possible mechanisms that may have contributed to improved bowel/ bladder function following locomotor training (Hubscher et al., 2018; Spungen et al., 2014)), however, none of the included studies tested the discussed mechanisms. None of the included studies reported on participant medication use or participation in activity outside of the study.

Table 3

*Study Protocol and Results of Articles Included in the Scoping Review*

<u>Authors/ Study Design</u>	<u>Intervention</u>	<u>LT Outcomes</u>	<u>Bowel/Bladder Outcomes</u>
Miller et al., 2016  Review with meta-analysis	Exoskeleton (8 ReWalk, 3 Ekso, 2 Indego, 1 unidentified). Training programs were usually conducted 3 times a week, for 60- 120 min, for a duration of 1 -24 weeks.	Following the exoskeleton training program, 76% (95% CI: 59%–90%) of patients were able to ambulate with no physical assistance.  6MWT: mean distance=98 m (95% CI: 80–117 m).	The meta-analysis looked at 14 studies, with only 3 having bowel outcomes. Improvements in bowel movement regularity were reported in 60.9% of participants (95% CI: 19.5-94.5%)

<p>Hubscher et al., 2018</p> <p>Controlled study, pre/post evaluation</p>	<p>80 daily one-hour sessions of LT on a treadmill using body-weight support, or one-hour of LT and stand training on alternate days.</p>	<p>LT outcomes were not collected.</p>	<p>Significant increases in bladder capacity (<math>p = 0.02</math>, <math>155.5 \pm 76.1</math> vs <math>278.5 \pm 147.8</math> ml), voiding efficiency (<math>p = .046</math>; <math>39.6 \pm 15.5\%</math> vs <math>63.9 \pm 8.9\%</math>) and detrusor contraction time as well as significant decreases in voiding pressure (<math>p &lt; 0.01</math>, <math>63.8 \pm 18.3</math> vs <math>42.7 \pm 18.6</math> cm H<sub>2</sub>O) were seen post- training relative to baseline as indicated by urodynamic assessment. There were no significant differences in fill volumes at first sensation pre- versus post-training and no differences in the maximum detrusor pressure (<math>64.9 \pm 34.8</math> cmH<sub>2</sub>O vs <math>59.6 \pm 30.4</math> cmH<sub>2</sub>O).</p> <p>Self-report indicated a decrease in the frequency of nocturia and urinary incontinence for several participants as well as a significant decrease in time required for bowel emptying (<math>p = 0.022</math>, <math>57.9 \pm 18.2</math> vs <math>35.7 \pm 26.2</math> min). Frequency of defecation decreased from 37.5% of participants daily to 25% daily. Oral laxative use decreased from 43% of participants to 37.5%.</p>
<p>Morrison et al., 2018</p>	<p>Manually assisted LT in a body weight-supported treadmill environment, as per</p>	<p>Significantly improved function on all measures:</p>	<p>Significantly improved bowel and bladder outcomes following 120 sessions:</p>

Prospective observational cohort with longitudinal follow-up	NRN guidelines, over-ground standing and stepping activities, and community integration tasks (120 sessions).	<ul style="list-style-type: none"> <li>- 10MWT – increased from median 0.0 m/s (interquartile range 0-0.22 m/s) to median 0.38 m/s (interquartile range 0.18-0.67 m/s).</li> <li>- 6MWT – increased from median 13 m (interquartile range 0-73 m) to median 115 m, interquartile range 62-186 m).</li> <li>- BBS – increased from 11±11 to 23±18.</li> </ul>	<ul style="list-style-type: none"> <li>- Leak prevention - # of participants showed change (worse 1, unchanged 17, better 6).</li> <li>- Voluntary sphincter control - # of participants showing change (worse 1, unchanged 15, better 8).</li> <li>- Stool continence - # of participants showed change (worse 1, unchanged 15, better 8).</li> <li>- Awareness of bladder need - # of participants showed change (worse 2, unchanged 17, better 5).</li> <li>- Bowel movement sensation - # of participants showed change (worse 0, unchanged 19, better 5).</li> </ul>
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		<ul style="list-style-type: none"> <li>- SCI-FAI – 3 participants decreased, 28 unchanged, 37 improved</li> </ul>	
Di Vico et al., 2017	<p>For patients with complete lesions- 20 Functional Electrical Stimulation cycling sessions (3-5 times a week) and 20 Ekso sessions. Patients with incomplete lesions- 20 Lokomat sessions (static Exoskeleton-assisted walking) and 20 FES sessions for the inferior limbs. Each session lasted</p>	<p>LT outcomes were not collected.</p>	<ul style="list-style-type: none"> <li>- Method of bladder management did not change for any participants following intervention.</li> <li>- UTIs – 8/15 patients reported more than 1 episode in the 6 months before intervention, only 4/15 reported more than 1 after treatment.</li> <li>- Bowel Evacuation (BE) - Among the 8 participants with complete SCI lesions, 0 reported more than 2 evacuations per week, 3 had more than 2 after treatment. Among the 7 participants with incomplete SCI lesions, 5 had more than 2 evacuations per week before treatment, while all 7 reached at least this frequency after treatment. Magnitude or effect size not specified.</li> </ul>
Controlled study, pre/post evaluation			

	between 30 and 60 minutes.		
Herrity et al., 2016  Controlled study, pre/post evaluation	LT on treadmill, bodyweight support system, or standing frame. 80 daily, 1-hour session.	LT outcomes were not collected.	Urodynamic assessments were performed at pre-and post-training time points, revealing significant increases in bladder capacity and detrusor contraction time, as well as a significant decrease in voiding pressure post-training. Magnitude and effect size not specified.
Spungen et al., 2014  Controlled study, pre/post evaluation	Exoskeleton Assisted Walking (EAW) for 4-6 hours a week.	The time needed to complete a 10MWT decreased significantly with exoskeletal training for EAW sessions 5-12 to sessions 28-36 (p=0.0001). The distance traveled during the 6MWT increased significantly for	The mean scores on both the 10Q BFS and SCI-QOL decreased significantly after 36 EAW training sessions (p=0.003 and p= 0.03, respectively). There was also a trend to a more desirable stool (less hard) on the BSS. These measures returned to baseline values within one month after intervention termination.

		EAW sessions 5-12 to sessions 28-36 (p= 0.0008). Specific data were not available.	
Fineberg et al., 2013	Exoskeleton. 1.5 – 2- hour session. 3 sessions per week, for 5 months.	LT outcomes were not collected.	All 4 participants reported worsening bowel function during training. Measures were taken at baseline, during training and 1-month post- training. <u>BEtime:</u> Patient 1 - 90, 30, and 90-120 minutes; Patient 2 - lost ability to have a "natural" BE Patient 3 – 60, 30 and 60-90 minutes Patient 4 – 90, 30 and 60-90 minutes <u>BEfreq:</u> Patient 1 - 1-2 x , 3-4 x , and 1-2x per week; Patient 2 - lost ability to have a "natural" BE; occasional use of a laxative pre and post, but not during training. Patient 3 - weekly use of laxative pre and post, but not during training. Patient 4 - weekly use of a stool softener and/or a laxative pre and post, but not during training. <u>BSS:</u>
Controlled study, pre/post evaluation			



			<p>Patient 1 - 3, 4, and 3</p> <p>Patient 2 – 2, 4, and 1</p> <p>Patient 3 - 1, 4 and 1</p> <p>Patient 4 - 4, 5 and 2</p>
Raab et al., 2016	Exoskeleton. Training was conducted 3 times a week (2x60 min, 1x30 min) for 7 months.	BBS improved from 7 to 34,  DGI score improved from 0 to 18.	Patient reported he/she regained partial control of bladder and bowel; magnitude and effect size not specified, as outcome was patient report only.
Single case study			
Kozlowski et al., 2015	Exoskeleton. Participants were given up to 24 weekly sessions. Walking time ranged from 28-94 min.	The longest walk ranged 561 to 2,616 steps (28 to 94 min).  The longest 2-minute walk distance ranged from 13.8 to 24.9m with average speeds of 0.11- 0.21 m/s.	2 participants anecdotally reported more regular bowel movements that were easier to manage after walking sessions. Magnitude and effect size not specified, as outcome was patient report only.
Longitudinal cohort design with a convenience sample, pre/post evaluation			

Black-Bain, 2014	Exoskeleton, orthotic bracing. 2-3 days a week for 6 weeks of exoskeleton training, 1-2 sessions a week of orthotic bracing.	Reduction in TUG score of 28.64 seconds. Increase in functional household ambulation to 77ft (an improvement of 72 ft).	No anecdotally reported change in bowel/bladder function.
Single case study			
Esquenazi et al., 2012	Exoskeleton. Training occurred for up to 24 sessions over the course of 8 weeks (60- 90 min per session)	LT outcomes were not available for non-exoskeleton-assisted walking. All participants, initially non-ambulatory, were able to walk on their own without human assistance for at least 50-100 m continuously and over a period of 5-10	5 of 11 participants provided anecdotal reports of improvements in bowel regulations. Magnitude and effect size not specified.
Open, noncomparative, non-randomized study			

mins with help from  
the exoskeleton.

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*Note.* CI= confidence interval; SCI- FAI= spinal cord injury functional ambulation inventory; QOL=quality of life; SCI=spinal cord injury; BE=bowel evacuation; Betime= bowel evacuation time; BEfreq= bowel evacuation frequency; SC=stool consistency; CIC=intermittent catheterization; DGI= dynamic gait index; TUG= timed up and go; BSS= bristol stool scale; 6MWT= six minute walk test; 10MWT= ten meter walk test; 10Q BFS= 10 question bowel function survey

## 2.4 Discussion

The key findings from this scoping review are: (1) there is a limited amount of literature available describing a relationship between LT and bowel/bladder function, however what exists generally describes a positive effect; (2) improvements in bowel/bladder function were observed regardless of modality used (e.g., Ekso, Lokomat, bodyweight support treadmill training); (3) just over half of the studies characterized bowel/bladder changes using physical measures rather than patient-reported outcomes; (4) two of the reviewed studies discussed possible underlying mechanisms responsible for bowel/bladder improvements following LT in humans.

### 2.4.1 Relationship of Locomotor Training and Bowel and Bladder Function

Due to the variety of measurements used for the assessment of bowel/bladder outcomes, results from various LT modalities cannot be directly compared against each other and therefore we cannot definitively conclude that there is a relationship between bowel/bladder outcomes and LT. Six studies identified specific objective procedures to measure the outcome (e.g., urodynamic assessments, measurement of stool consistency, frequency of UTIs), while five articles provided anecdotal evidence from the participants of bladder or bowel improvements (e.g., reduced reliance on laxatives, reduced voiding pressure).

It is worth noting that in the five studies that reported positive locomotor outcomes, positive changes in bowel and bladder function following LT were also reported. Although these findings suggest that bowel/bladder outcomes may be positively correlated with improvements in LT, further research is required to explore the mechanisms behind why LT outcomes and bowel/bladder outcomes may improve together. Currently it is unknown whether standing alone, walking, or even passive lower limb movement is necessary for bowel/bladder improvements. Since the mechanisms behind bowel/bladder improvements and LT are still unknown in both able-bodied

individuals and individuals with SCI, it is difficult to identify one specific mode of LT that would elicit the best bowel/bladder outcomes. Spungen and colleagues (2014) suggested that it may be the activation of the abdominal musculature and, possibly, the action of ambulation itself that contributes to the stimulation of colonic motility and therefore leads to improvements in bowel function. In addition, Hubscher and colleagues (2018) suggested that potential impacts on bowel and bladder function may be due to afferent input associated with LT. The authors hypothesize that the chronic activation of lumbosacral spinal circuits might lead to adaptive changes in other systems such as those controlling bowel/bladder function. However, these mechanisms were not tested with experimental manipulation in either reported study.

#### 2.4.2 Measurement of Bowel and Bladder Outcomes

Across the studies identified in this review, measurements of bowel and bladder function were diverse. The lack of a uniform reporting system makes it difficult to compare these outcomes against one another and draw any meaningful overall conclusions. Six studies solicited patient reports of bowel/bladder changes, however, only two of the studies (Hubscher et al., 2018; Spungen et al., 2014) utilized standardized PROs for this purpose. PROs can become a favorable mode of recording bowel and bladder change in the future given their ease of administration: no specialized equipment or personnel are needed, which may also speak to improved cost effectiveness or feasibility (Nixon et al., 2017). PROs also provide a valuable patient perspective on how an intervention impacts their daily life. In a study by Spungen and colleagues (2014), the SCI-QOLv1.0 Bowel Management Difficulties Short Form was used to assess bowel function changes following LT. The SCI-QOLv1.0 Bowel Management Difficulties Short Form is one of the three assessments within the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales, a PRO developed and validated by Tulskey and colleagues (2015). Given the high involvement from the SCI community during the development of these scales (Tulskey et al., 2015) this PRO may be a suitable instrument for measuring bowel and bladder changes following LT.

### 2.4.3 Opportunities for Future Study

Currently there is limited literature available examining the relationship between LT and bowel/bladder outcomes following SCI. Evidence associated with bowel and bladder changes with SCI is emerging but limited. Some of the studies selected for this review were case studies and pilot studies and therefore may not have had sufficient power to assess bowel/bladder outcomes. Hence, pre and post studies with larger participant numbers are necessary to further explore the relationship between LT and bowel/bladder function. Given that 98% of individuals living with SCI will experience some form of bowel dysfunction and 95% will experience some form of bladder dysfunction, it is surprising that bowel/bladder outcomes following LT are not studied more frequently (Burns et al., 2015). This may be due to the cost, effort, or expertise associated with administering clinical measures. Clinically, physiotherapists perform locomotor training, and assess changes in physical function, trunk control, and mobility, but the physiological measures of bowel and bladder function are most often performed by nursing and medicine. The use of PROs may make evaluation of bowel/bladder outcomes with LT easier to implement and more cost efficient, therefore increasing the number of studies examining these outcomes.

## 2.5 Conclusion

Currently, there is limited evidence available regarding bladder and bowel improvements following locomotor training. Some of the evidence identified by the present review is anecdotal and not systematically collected. Studies identifying bowel and bladder function as a primary outcome are emerging, however, the evidence is still minimal. Further research is needed to examine the nature of the relationship between locomotor training and bladder and bowel outcomes, as well as underlying mechanisms responsible for the relationship.

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## 3 Spinal Cord Injury-Quality of Life v1.0 Bowel and Bladder Dysfunction Scales: A feasibility study

### 3.1 Introduction

Bowel and bladder dysfunction is experienced by 98% of individuals who experience a spinal cord injury (SCI) (Burns et al., 2015; Cameron et al., 2015). Due to the high prevalence and significant impact on quality of life (QOL; Akkoç et al., 2013) it is not surprising that bowel and bladder dysfunction is also consistently ranked in the top four health concerns by those living with SCI (Simpson et al., 2012). Bowel and bladder dysfunction occur due to the interruption of the autonomic nervous system and sacral spinal nerves S2-4 which control bladder and bowel retention and emptying. Importantly, the type of dysfunction depends on the level and completeness of injury sustained. Individuals experiencing a complete SCI experience more severe bowel and bladder dysfunction (Hsieh et al., 2014). There are two distinct clinical presentations of bowel dysfunction: injury above the conus medullaris typically results in upper motor neuron (UMN) bowel syndrome. Injuries below the conus medullaris result in a lower motor neuron (LMN) bowel syndrome. Similarly, bladder dysfunction is also a product of disruption in the connectivity in the sacral region. Individuals with UMN injuries are most likely to present with external sphincter dyssnergia or hyperflexic bladder (Minassian et al., 2016). Individuals with LMN injuries are more likely to present with the detrusor areflexia or flaccid bladder (Minassian et al., 2016).

Locomotor training (LT) is used in SCI rehabilitation to improve postural control, standing, and walking (Harkema et al., 2012). In addition to the primary goals of improving ambulation, LT has also shown potential in reducing pain and spasticity in individuals with SCI (Quel de Oliveira et al., 2017; Manella & Field-Fote, 2013). Recently, LT has also shown promise in improving bowel and bladder function in individuals with SCI (Morrison et al., 2018). The limited evidence available comes from predominantly anecdotal reports by participants and clinical measures assessing the frequency of bowel evacuation and consistency, as well as measures assessing the residual urine volumes, filling and emptying bladder pressures, and other urodynamics

procedures. However Hubscher and colleagues (2018) and Spungen and colleagues (2014) reported the use of PROs to assess bowel and bladder outcomes in their studies. PROs are an effective and cost-efficient way to measure the impact of an intervention from the participant's perspective (Nixon et al., 2018).

The SCI-QOL Bowel and Bladder Dysfunction Scales are PROs that were developed by David Tulsy and colleagues to measure the level of bowel and bladder dysfunction in individuals with SCI. The scales were validated for assessment of bowel and bladder management difficulties and complications on quality of life for individuals with SCI (Tulsy et al., 2015). These scales are psychometrically robust and are available as computer adaptive tests or short form (Tulsy et al., 2015). Individuals with SCI were involved throughout the entire process in the development of the questionnaires (Kisala et al., 2015). To be a part of the development process, individuals had to have a traumatic SCI and reside in the community. Those participating in the development process were predominantly male (79.1%) and only 28.9% were <1 year post injury (Tulsy et al., 2015). All the involved participants were community-dwelling. Although the extensive involvement of the targeted population resulted in a set of items that was both relevant and comprehensive (Kisala et al., 2015), the limited involvement or input from women, individuals experiencing non-traumatic SCI, and individuals currently residing in rehabilitation settings may reduce the relevancy of these measures.

One of the ways to test whether an intervention or an instrument is appropriate or relevant for the intended population is to conduct a feasibility study (Bowen et al., 2009). Feasibility studies aim to identify not only what needs to change within the protocol of an intervention or instrument, but how these modifications may take place to accommodate a specific setting for implementation. In addition, feasibility studies can be used to assess whether an intervention or instrument can be applied to a population for which it was not originally designed. A comprehensive framework for conducting feasibility studies was outlined in Bowen et al., 2009. The framework identified focused sub-domains that can be explored through research. These sub-domains include acceptability, demand,

implementation, practicality, adaptation, integration, expansion, and limited-efficacy testing (Bowen et al., 2009).

The primary objective of this study was to test the feasibility of using SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales to assess bowel and bladder dysfunction in individuals with SCI participating in inpatient or outpatient rehabilitation. The secondary objective was to explore any differences in feasibility in individuals participating in inpatient versus outpatient rehabilitation. The feasibility assessment framework described by Bowen (Bowen et al., 2009) was used to assess the feasibility subdomains of acceptability, implementation, practicality, and limited efficacy. The hypothesis was that the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales would be deemed generally feasible on all subdomains for outpatients and less feasible for inpatients.

## 3.2 Methods

### 3.2.1 Participants

Participants were invited to participate in this cross-sectional study if they were 18 years of age or older, actively participating in physiotherapy services for a traumatic or non-traumatic SCI at Parkwood Institute's outpatient and inpatient SCI rehabilitation programs (London, ON). Parkwood Inpatient SCI program has 15 beds and eligibility requires patients to be medically stable, have restorative potential, and be motivated and willing to participate in rehabilitation. There were no restrictions on length of time from injury. Parkwood Outpatient SCI program eligibility is identical to the Inpatient program eligibility requirements. Participants provided written or verbal consent either themselves or through a substitute decision maker. Ethics approval was obtained from Western University's Research Ethics Board (REB) and Lawson Health Research Institute.

### 3.2.2 Recruitment

Eligible participants were recruited from Parkwood Institute's Inpatient SCI Program and Outpatient SCI Program. Parkwood's SCI Program physiotherapists and occupational therapists identified eligible patients and provided them with a summary of the study and asked the patient if they were interested in participating. The clinicians alerted the

researchers of those interested. Researchers obtained informed consent prior to enrolling the participant in the study.

### 3.2.3 Measures

Participant demographic data abstracted from charts included admission status (inpatient or outpatient rehabilitation), sex, age, injury descriptor (traumatic or non-traumatic SCI), c-SWAT stage, and bowel and bladder management scores from the Functional Independence Measure (FIM). The c-SWAT was used to describe the participants' standing and walking ability. The FIM was used to describe the level of assistance needed for bladder and bowel management. Summary scores for SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were calculated to describe severity of dysfunction.

#### 3.2.3.1 Canadian Standing and Walking Assessment Tool (c-SWAT)

The c-SWAT is a classification tool for standing and walking function. The c-SWAT also assists clinicians in determining an individual's readiness to progress with their standing and walking skills, establishing realistic therapy goals, and developing individualized rehabilitation plans. The c-SWAT grades range from 0 to 4 (0= non-independent sitting—4= full walking capacity; Craven et al., 2012).

#### 3.2.3.2 Functional Independence Measure

The Functional Independence Measure (FIM<sup>TM</sup>; Appendix 5) measures the level of an individual's disability through the determination of the level of assistance necessary for completion of daily tasks (Masedo et al., 2005). The FIM<sup>TM</sup> is scored on a scale from 1-7 (1= Total Assistance, 2=Maximal Assistance, 3=Moderate Assistance, 4=Minimal Assistance, 5=Supervision, 6=Modified Independence, 7=Complete Independence; Coding, 2018). Only FIM bladder and bowel management sub-scores were collected in this study.

### **3.2.3.3 SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales**

The SCI-QOL v1.0 Bowel and Bladder Dysfunction Scales is comprised of 3 individual subscales that pertain to bowel and bladder function. The three subscales are SCI- QOL v1.0 Bladder Complications Scale, SCI- QOL v1.0 Bladder Management Difficulties Short Form, and SCI- QOL v1.0 Bowel Management Difficulties Short Form. For each subscale, Item Response Theory (IRT) Analysis was used to scale a pool of test items along a single underlying metric. Construct unidimensionality was assessed with the use of a graded-response IRT model (Tulsky et al., 2015).

### **3.2.3.4 SCI-QOL v1.0 Bladder Complications Scale**

This scale assesses possible bladder complications from a urinary tract infection (UTI). This self-report instrument is comprised of six items and each is graded on a 5-point Likert scale. Each item is graded based on the frequency of the event described, with a score of one meaning “Not At All” and a score of five meaning “Always”. Severity of bladder complications is assessed based on the summary score obtained after adding all the individual statement scores. Summary scores may range from 6 to 30, with a score of 6 denoting no bladder complications and a score of 30 denoting severe bladder complications (Tulsky et al., 2015). Test/re-rest reliability (Pearson’s  $r=0.70$ ) and internal consistency (Cronbach’s  $\alpha=0.79$ ) were tested by Tulsky and colleagues (2015). The scales were also validated for individuals with traumatic SCI by Tulsky and colleagues (2011). (Appendix 1)

### **3.2.3.5 SCI-QOL v1.0 Bladder Management Difficulties Short Form**

This self-report outcome measure is comprised of eight items and is graded on a 5-point Likert scale. Each item is graded based on the frequency of the event described, with a score of one meaning “Not At All” and a score of five meaning “Always”. The scale is used to assess bladder management difficulties (e.g., bladder incontinence) that may be experienced by individuals with SCI. Severity of bladder management difficulties is assessed based on the summary score obtained after adding all the individual statement scores. Summary scores may range from 8 to 40, with a score of 8 denoting no bladder



management difficulties and a score of 40 denoting severe bladder management difficulties (Tulsky et al., 2015). Test/re-rest reliability (Pearson's  $r=0.77$ ) and internal consistency (Cronbach's  $\alpha=0.91$ ) were tested by Tulsky and colleagues (2015). The scales were also validated for individuals with traumatic SCI by Tulsky and colleagues (2011). (Appendix 2)

### **3.2.3.6 SCI-QOL v1.0 Bowel Management Difficulties Short Form**

This self-report scale is comprised of nine items and is graded on a 5-point Likert Scale (1-5). Each item is graded based on the frequency of the event described, with a score of one meaning "Not At All" and a score of five meaning "Always". This scale is used to assess bowel management difficulties (i.e., neurogenic bowel) that may be experienced by individuals with SCI. Severity of bowel management difficulties is assessed based on the summary score obtained after adding all the individual statement scores. Summary scores may range from 9 to 45, with a score of 9 denoting no bowel management difficulties and a score of 45 denoting severe bowel management difficulties (Tulsky et al., 2015). Test/re-rest reliability (Pearson's  $r=0.74$ ) and internal consistency (Cronbach's  $\alpha=0.95$ ) were tested by Tulsky and colleagues (2015). The scales were also validated for individuals with traumatic SCI by Tulsky and colleagues (2011). (Appendix 3)

### **3.2.3.7 Feasibility Survey for Participants**

This survey was used to gain participant insight into the acceptability, implementation, practicality and limited efficacy of the Bowel and Bladder scales (see Appendix 4). This was a customized survey that was developed by the researcher in adherence with the Bowen framework of feasibility testing (Bowen et al., 2008). Statements addressing the domains of Acceptability (two questions), Implementation (one question), Practicality (four questions), and Limited Efficacy (three questions) were included, for a total of 10 statements, were self-reported, and were graded on a Likert scale (-3 to +3), with -3 being strong disagreement with the statement and +3 strong agreement. Participants also had the option of marking a question as "Not Applicable". The Feasibility Survey for

Participants also included a comment section, where participants could provide feedback on the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales.

### 3.2.4 Procedure

Once informed consent was obtained, participants were asked to complete the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales and Feasibility Survey for Participants. Assistance was provided if the participant had limited hand function and was unable to complete the questionnaire independently. In addition, participant data was abstracted from patient charts by the researcher when charts became available.

### 3.2.5 Data Analysis

#### 3.2.5.1 Demographic Information and Clinical Characteristics

Participant demographic information, c-SWAT and FIM™ scores were compiled in a table (Table 4) to describe the sample. The three subscales of the bowel and bladder dysfunction scales were summated to create a summary score (Tulsky et al., 2015).

#### 3.2.5.2 Feasibility of SCI-QOL v1.0 Bowel and Bladder Dysfunction Scales

The frequency distribution of responses for each feasibility sub-domain within the Feasibility Survey for Participants (i.e., acceptability, implementation, practicality, limited efficacy) were summarized in histograms for visual inspection. Only positive and negative responses were displayed in histograms. Responses of “Not Applicable” and participant comments pertaining to the feasibility of the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were collated in tables and presented in the sections of the most pertinent sub-domain.

Additional analyses were performed to evaluate the sub-domains of acceptability and limited efficacy. Acceptability was evaluated with visual inspection of frequency distribution of response to the survey questions pertaining to acceptability, reporting of participant feasibility survey comments on acceptability, and reporting of bowel and bladder dysfunction scale questions deemed “Not Applicable” by participant. This was

done to ensure robustness of evaluation and representation of the participants' perceptions of the appropriateness of the measures. Participant comments and questions identified as not applicable were summarized in table format.

The following three methods were used to assess limited efficacy, as recommended in Bowen et al., 2009:

1. Agreement with limited efficacy-related questions on the Feasibility Survey for Participants
2. Calculation of the effect/sample size.
3. Evaluation of whether the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales fulfil their intended purpose of assessing bowel and bladder management difficulties in individuals with SCI.

The sample size calculation was conducted using G\*Power 3.1.9.2. Evaluation of whether the scales fulfilled their intended purpose was conducted through inspection of various summary scores and simple descriptive statistics associated with these scales. The SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales summary scores were calculated by adding individual scores from each question (Tulsky et al., 2015), and descriptive statistics were used to calculate the mean and standard deviation. These summary scores informed the evaluation of limited efficacy, as a measure of bowel/bladder dysfunction severity across the sample. In addition, a calculation of Spearman's Rho using SPSS (IMP SPSS Statistics Version 25) was conducted between the FIM™ scores and the summary scores of the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales to explore a possible relationship between independence with bowel/bladder management and severity of bladder complications, severity of bladder management difficulties, and severity of bowel management difficulties.

### 3.2.5.3 Differences in Feasibility Between Inpatients and Outpatients

To determine whether the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were feasible for both inpatients and outpatients, responses to the Feasibility Survey for Participants were analysed using chi-square test for independence in SPSS (IBM SPSS Statistics Version 25). This test was conducted to assess if there were differences in response patterns for the various subdomains of feasibility between inpatients and outpatients. Each individual question in the Feasibility Survey for Participants was analysed separately. For the analysis, answers to the survey were dichotomized with +1, +2 and +3 answers classified as “agree”, and 0, -1, -2, -3 as “not agree”.

## 3.3 Results

### 3.3.1 Participants

Eleven individuals participated in the feasibility study (6 Inpatient, 5 Outpatient; 8 Male, 3 Female). All participants who were recruited completed the study. Complete summary of participant information is presented in Table 4.

Table 4

#### *Participant Demographic and General Injury Characteristics*

<u>Participant ID</u>	<u>Rehabilitation</u>			<u>Injury</u>	
	<u>Status</u>	<u>Sex</u>	<u>Age</u>	<u>Descriptor</u>	<u>c-SWAT Stage</u>
1009	OP	M	38	Traumatic	2B
1010	OP	M	27	Traumatic	3C
1018	OP	M	25	Traumatic	1A
1019	IP	F	60	Non-Traumatic	1B
1020	OP	F	66	Traumatic	1B

1021	OP	M	51	Traumatic	1A
1022	IP	M	56	Traumatic	0
1023	IP	F	52	Non-Traumatic	2B
1025	IP	M	75	Non-Traumatic	Unknown
1026	IP	M	51	Non-Traumatic	Unknown
1027	IP	M	34	Traumatic	2C

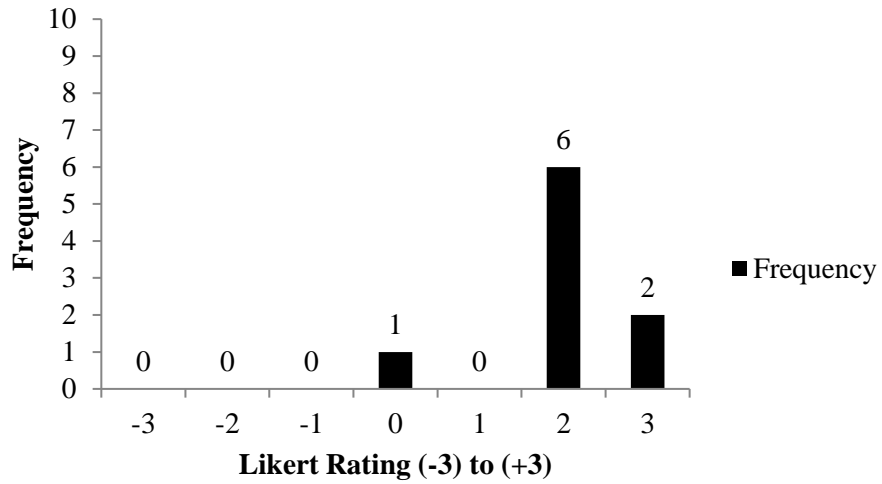
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*Note.* IP= inpatient rehabilitation, OP= outpatient rehabilitation, c-SWAT= Canadian Standing and Walking Assessment Tool; Assessments to determine the c-SWAT Stage for participants 1025 and 1026 were not concluded at the time of data extraction.

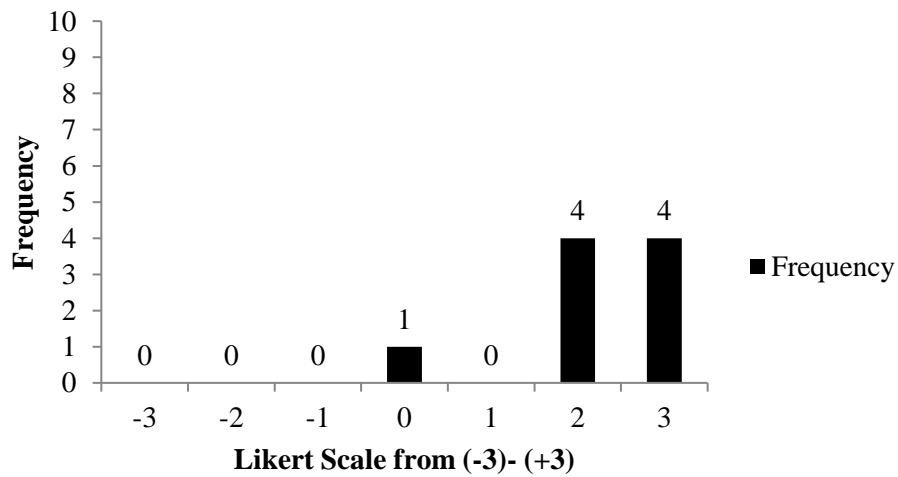
### 3.3.2 Feasibility of SCI-QOL v1.0 Bowel and Bladder Dysfunction Scales

#### 3.3.2.1 Acceptability

Participants were in general agreement that the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were acceptable. All but one participant indicated either agreement or strong agreement for both questions related to acceptability. Some participants provided comments and/or indicated some questions were “not applicable.”



*Figure 2.* The extent to which participants agreed with the phrase “You are fully satisfied with the SCI-QOL Bowel and Bladder assessments.” on the Participant Feasibility Survey. Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).



*Figure 3.* The extent to which participants agreed with the phrase “You believe SCI-QOL Bowel and Bladder assessments were appropriate for you” from Feasibility Survey for Participants. Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).

### 3.3.2.1.1 Participant Comments on Acceptability

Three participants provided comments pertaining to the sub-domain of acceptability. All three comments expressed concerns about the applicability of the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales (see Table 5). All the respondents were enrolled in outpatient rehabilitation.

Table 5

#### *Participant Comments on the Acceptability of SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales*

<u>Participant</u>	<u>Comments</u>
<u>ID</u>	
1010	"There is no room for nuance with the questions maybe a bit more room for explanation."
1020	"Not applicable "bladder program in public". Not applicable for indwelling catheter."
1021	"Wording and ranking of questions seemed awkward."

### 3.3.2.2 Responses of “Not Applicable” on SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales

Four participants marked several questions in the SCI-QOL Bowel and Bladder Dysfunction Scales as “Not Applicable”; 3 of the respondents were inpatients (see Table

6). All 4 respondents indicated “I worried about performing my bladder program in public,” as not applicable.

Table 6

*Summary of Questions Marked as “Not Applicable” in the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales*

<u>Participant ID</u>	<u>Rehabilitation Status</u>	<u>Question marked N/A</u>
1019	IP	"I worried about performing my bladder program in public"
1020	OP	"I worried about performing my bladder program in public"
1022	IP	"I worried about performing my bladder program in public"
1022	IP	"Bladder issues limited my sex life"
1025	IP	"I was frustrated by bladder accidents"
1025	IP	"I worried about performing my bladder program in public"
1025	IP	"I worried about performing my bladder program"
1025	IP	"Bladder accidents have disrupted my daily activities"



1025	IP	"I worried that my social activities would be interrupted by a bowel accident"
1025	IP	"Bowel accidents limited my independence"
1025	IP	"I worried about performing my bowel program"

### 3.3.2.3 Implementation

Participants were in general agreement that the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were implemented correctly with all responses indicating either strong agreement for the question related to implementation. Three participants provided comments that pertained to implementation of the scales.

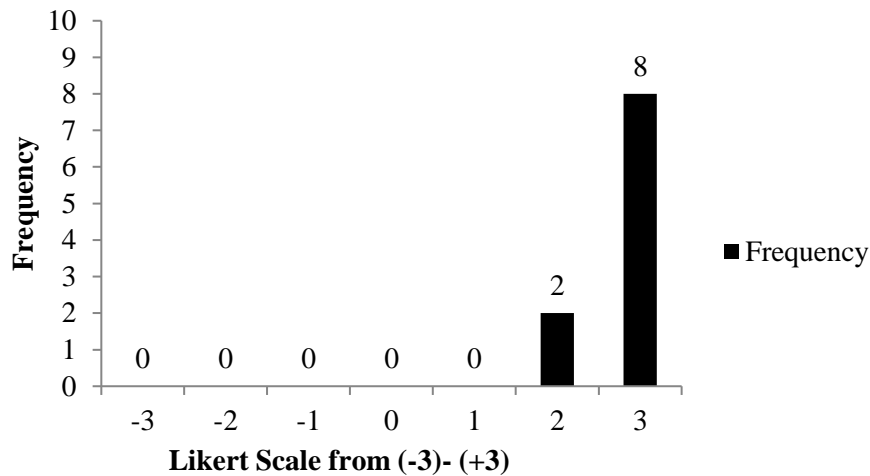


Figure 4. Frequency of responses for “You were provided sufficient resources (i.e., time, assistance) to complete SCI-QOL Bowel and Bladder assessments” from Feasibility Survey for Participants. Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).

### 3.3.2.3.1 Participant Comments on Implementation

Three participants provided comments pertaining to the sub-domain of implementation. All three comments expressed dissatisfaction with the timing of the assessment (see Table 6). All the respondents were enrolled in inpatient rehabilitation.

Table 7

#### *Participant Comments on the Implementation of SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales*

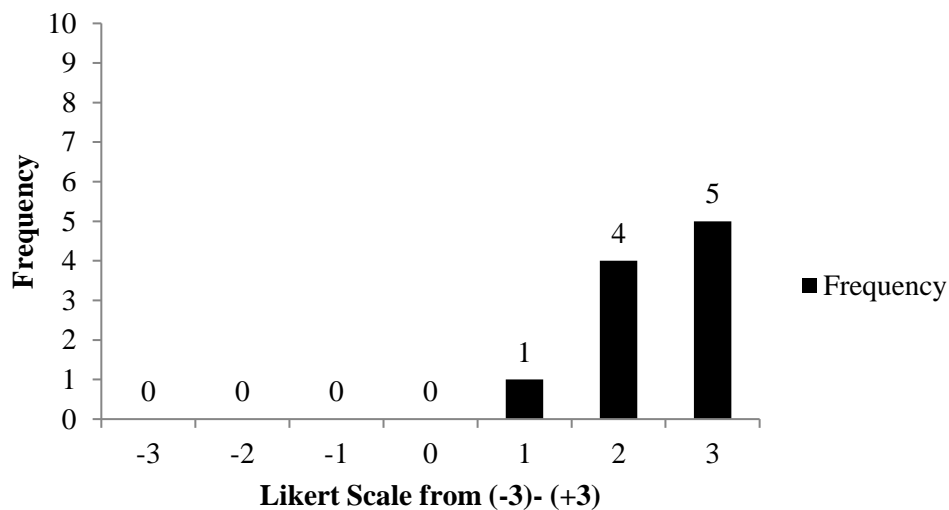
<u>Participant</u>	<u>Comments</u>
<u>ID</u>	
1022	"More timely delivery. Needs a post."

1023 "If assessment had been earlier in recovery the outcome would have been  
very different."

1025 "Too early to tell. Everything is changing."

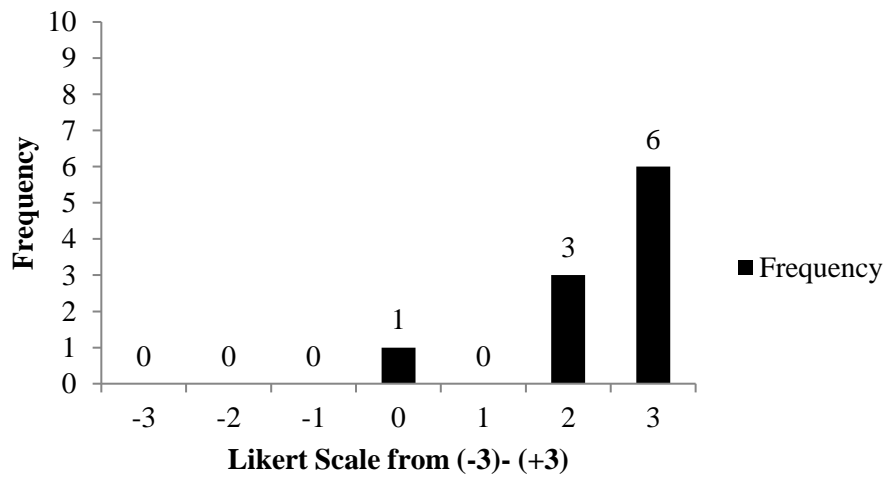
### 3.3.2.4 Practicality

Participants were in general agreement that the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were practical with all responses but two indicating either agreement or strong agreement for the questions related to practicality. Participants did not provide any comments pertaining to practicality.

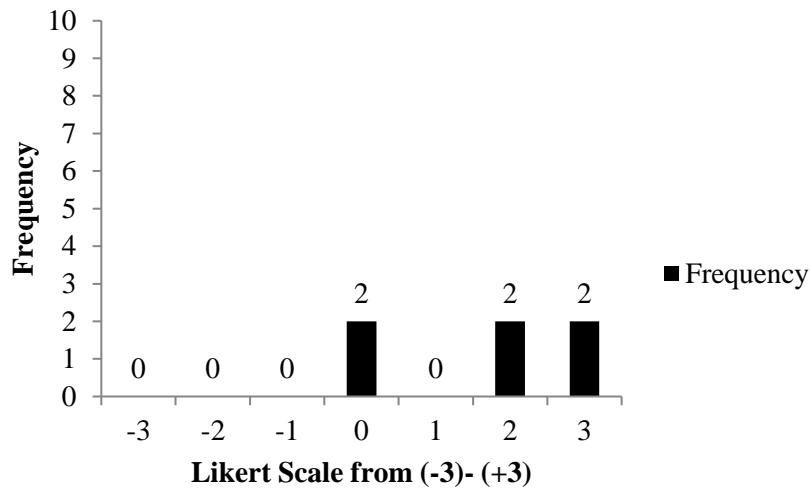


*Figure 5.* The extent to which participants agreed with the phrase “The SCI-QOL Bowel and Bladder assessments were easy to complete” from Feasibility Survey for Participants.

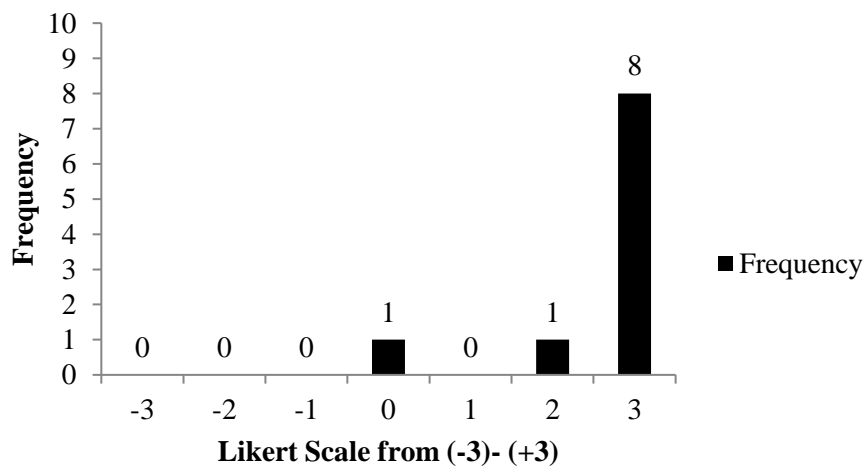
Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).



*Figure 6.* The extent to which participants agreed with the phrase “The SCI-QOL Bowel and Bladder assessments were conducted efficiently, at the right time, and with appropriate quality” from Feasibility Survey for Participants. Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).



*Figure 7.* The extent to which participants agreed with the phrase “The SCI-QOL Bowel and Bladder assessments had a positive effect on informing you of possible bowel and bladder changes you may be experiencing” from Feasibility Survey for Participants. Responses range from -3 to 3.

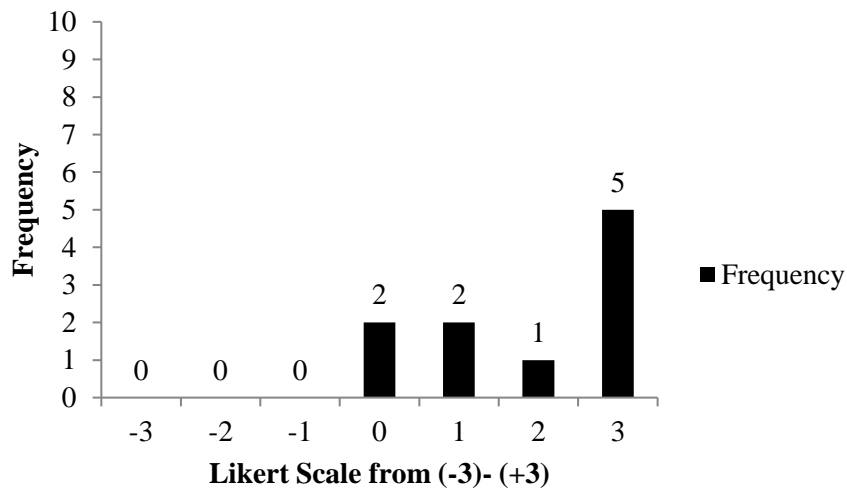


*Figure 8.* The extent to which participants agreed with the phrase “You have sufficient ability (i.e., upper extremity function) to carry out the assessments in the packages” from

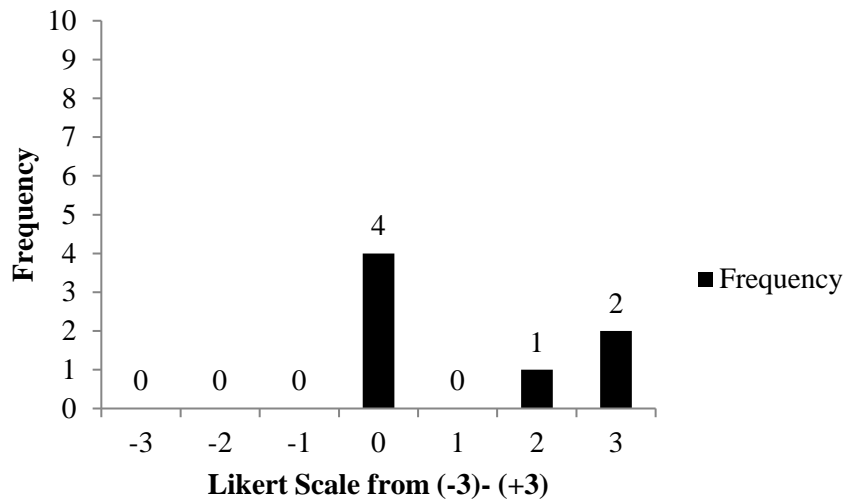
Feasibility Survey for Participants. Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).

### 3.3.2.5 Limited Efficacy

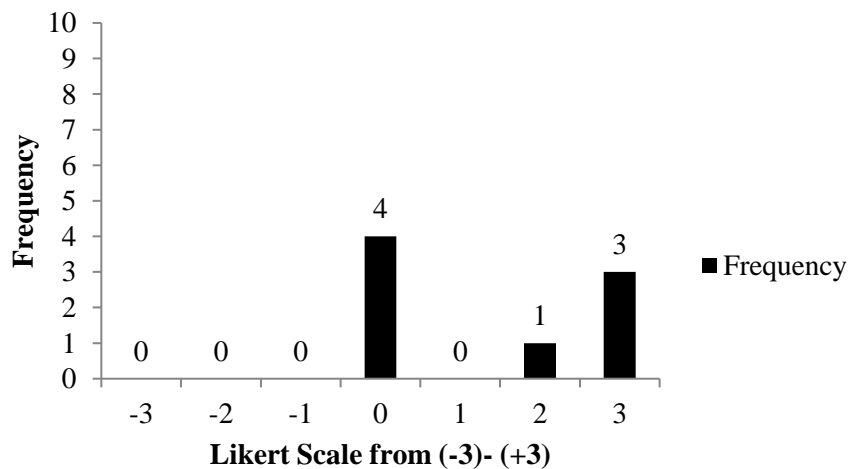
Participants did not reach a consensus that the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales satisfied the sub-domain of limited efficacy with responses ranging from dissatisfaction to strong agreement on all questions related to limited efficacy.



*Figure 9.* The extent to which participants agreed with the phrase “The SCI-QOL Bowel and Bladder assessments were appropriate to assess your bowel/bladder function” from Feasibility Survey for Participants. Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).



*Figure 10.* The extent to which participants agreed with the phrase “The SCI-QOL Bowel and Bladder assessments had positive effects on your rehabilitation goal setting” from Feasibility Survey for Participants. Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).



*Figure 11.* The extent to which participants agreed with the phrase “The SCI-QOL Bowel and Bladder assessments resulted in more meaningful interventions for you” from

Feasibility Survey for Participants. Responses range from -3 (Strongly Disagree) to 3 (Strongly Agree).

### 3.3.2.5.1 Limited Efficacy - Sample Size Calculation

A sample of 85 individuals may be necessary to observe a Minimal Detectable Change (MDC) when administering the SCI-QOLv1.0 Bladder Management Difficulties Short Form in a pre- and post-trial. A sample size calculation was only conducted for the SCI-QOLv1.0 Bladder Management Difficulties Short Form as the MDC was only available for this scale. The MDC of 12.3 was obtained from Stipp & Nitsch, 2016.

### 3.3.2.5.2 Limited Efficacy - Participant SCI-QOLv1.0 Bowel and Bladder Dysfunction Summary Scores and FIM Scores

Participants presented some variability on severity of bowel, and bladder dysfunction, as measured on SCI-QOL v.01 Bowel Management Difficulties Short Form (mean=13.8±7.38), SCI- QOL v1.0 Bladder Management Difficulties Short Form (mean=11.7±4.06), SCI- QOL v1.0 Bladder Complications Scale (mean=7.8±3.49). For the Bowel Management Difficulties Short Form scores ranged from 8 participants had scores ranging from 9-15 indicating a low level of bowel management difficulties. Two participants had scores of 32 and 33 indicating higher levels of bowel management difficulties. For the Bladder Management Difficulties Short Form all participants reported low levels of bladder management difficulties with scores ranging from 5-18. For the Bladder Complications Scale 9 participants indicated low levels of bladder complications with scores ranging from 6-10. One participant reported a score of 17 indicating a higher level of bladder complications.



Table 8

*Participant Summary Scores of SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales and FIM™ Bladder and Bowel Management.*

<u>Participant</u>	<u>FIM Bladder</u>	<u>FIM Bowel</u>	<u>SCI-QOLv1.0</u>		<u>SCI-QOLv1.0</u>
			<u>Bowel</u>	<u>Bladder</u>	
<u>ID</u>	<u>Management</u>	<u>Management</u>	<u>Management</u>	<u>Management</u>	<u>Bladder</u>
<u>Scores</u>	<u>Scores</u>	<u>Scores</u>	<u>Difficulties</u>	<u>Difficulties</u>	<u>Complications</u>
<u>(1-7)</u>	<u>(1-7)</u>	<u>(1-7)</u>	<u>Short Form</u>	<u>Short Form</u>	<u>Scale Summary</u>
			<u>Summary</u>	<u>Summary</u>	<u>Scores (6-30)</u>
			<u>Score (9-45)</u>	<u>Score (8-40)</u>	
1009	7	7	9	10	7
1010	Unavailable	Unavailable	15	10	6
1018	Unavailable	Unavailable	15	15	8
1019	1	5	Not Applicable	8	6
1020	Unavailable	Unavailable	32	18	6
1021	Unavailable	Unavailable	9	13	17
1022	1	4	11	11	10
1023	6	6	9	10	6
1025	5	6	15	5	6
1026	6	6	9	17	6
1027	7	6	33	13	6

---

*Note.* Functional Independent Measure (FIM™) is an instrument that measures the level of an individual's disability and the level of assistance necessary for completion of daily tasks (Masedo et al., 2005). The FIM™ is scored on a scale from 1-7 (1= Total Assistance, 2=Maximal Assistance, 3=Moderate Assistance, 4=Minimal Assistance, 5=Supervision, 6=Modified Independence, 7=Complete Independence; Coding, 2018). Participant responses of "Not Applicable" and questions left blank were assigned a score of zero.

### 3.3.2.5.3 Limited Efficacy - Spearman's Rho Correlation Coefficient

Spearman's Rho (Correlation Coefficient) was calculated between the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales summary scores and the FIM™ bladder and bowel scores using SPSS (IBM SPSS Statistics Version 25); no statistically significant relationships were found (see Table 8). Increased scores on the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales had poor correlations with reduced independence in bowel/bladder management, as reflected in the FIM™ scores. FIM™ scores for bladder and bowel management were available for seven participants (6 Inpatient, 1 Outpatient) (see Table 7).

Table 9

*Summary Table of Spearman's Rho (Correlation Coefficient).*

	<u>SCI-QOLv1.0</u>	<u>SCI-QOLv1.0</u>	<u>SCI-QOLv1.0</u>
	<u>Bowel</u>	<u>Bladder</u>	<u>Bladder</u>

	<u>Management</u> <u>Difficulties Short</u> <u>Form</u>	<u>Management</u> <u>Difficulties Short</u> <u>Form</u>	<u>Complications</u> <u>Scale</u>
Spearman's Correlation Coefficient (R)	R=-0.11447	R=0.388956	R= -0.35921

*Note.* Spearman's Rho is a non-parametric test used to measure the linear correlation between two variables. It has a value between +1 and -1, where 1 is total positive linear correlation, 0 is no linear correlation, and -1 is total negative linear correlation (Yeager, 2018),  $p = < .05$

### 3.3.3 Difference in feasibility for inpatient and outpatient participants

A Chi-square test for independence was calculated for the difference in frequency of responses between inpatients and outpatients on the Feasibility Survey for Participants. No statistically significant relationships were identified, meaning that responses to the Feasibility Survey for Participants did not vary depending on which group (inpatient or outpatient) a participant belonged to.

Table 10

*Results of Pearson's Chi Square Test for Independence*

<u>Statements</u>	<u>Analyses</u>
	Pearson's Chi-Square Asymptotic Significance (2-sided) $p$

---

You are fully satisfied with the SCI-QOL Bowel and Bladder assessments.	1.111	.292
You believe SCI-QOL Bowel and Bladder assessments were appropriate for you.	3.143	.370
The SCI-QOL Bowel and Bladder assessments were easy to complete.	Unable to calculate.	Unable to calculate.
The SCI-QOL Bowel and Bladder assessments were conducted efficiently, at the right time and with appropriate quality.	1.111	.292
The SCI-QOL Bowel and Bladder assessments had a positive effect on informing you of possible bowel and bladder changes you may be experiencing.	1.111	.292
You have sufficient ability (i.e., upper extremity function) to carry out the assessments in the packages.	.533	.776
You have sufficient ability (i.e., upper extremity function) to carry out the assessments in the packages.	1.111	.292
The SCI-QOL Bowel and Bladder assessments were appropriate to assess your bowel/bladder function.	.000	1.000

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The SCI-QOL Bowel and Bladder assessments had positive effects on your rehabilitation goal setting.	2.000	.368
The SCI-QOL Bowel and Bladder assessments resulted in more meaningful interventions for you.	2.000	.368

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### 3.4 Discussion

This study examined the feasibility of using the SCI-QOL v1.0 Bowel and Bladder Dysfunction Scales to assess bowel and bladder dysfunction in individuals with SCI undergoing rehabilitation. This study also examined whether the scales were deemed feasible for both inpatients and outpatients, or less so for inpatients. Based on the results of the Feasibility Survey for Participants, the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were deemed mostly feasible in both inpatient and outpatient settings. In both settings, participants found the scales to be practical and contributing to limited efficacy. However, in the sub-domain of implementation, some inpatients felt unsatisfied with the timing of evaluation and felt that assessment should have been done earlier in their inpatient stay. Both inpatients and outpatients (3 inpatients, 1 outpatient) also identified 9 of 23 questions from The SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales as not applicable for them and therefore were not completely satisfied with the acceptability of the scales.

#### 3.4.1 Acceptability

Nine of twenty-three questions from SCI-QOL v1.0 Bowel and Bladder Dysfunction Scales were identified by individuals enrolled in inpatient and outpatient rehabilitation as not applicable for them. Specifically, questions concerning performing bowel/bladder programs in public spaces and the social impacts of bowel/bladder dysfunction were answered as non-applicable or left blank. These findings suggest that although 14 of 23 questions on the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales are relevant for

individuals enrolled in inpatient rehabilitation, there are two sub-domains of the questionnaires that may not be as applicable, specifically the possible impact of bowel and bladder dysfunction on social engagement and performing bowel and bladder programs in public.

Individuals participating in inpatient rehabilitation for example may have different concerns and difficulties with bowel/bladder function than their outpatient counterparts. Questions concerning the performance of bowel/bladder programs in public spaces may be not applicable for inpatients as participants may still depend on nursing staff for their programs or have limited exposure to public spaces outside of the rehabilitation facility. Questions concerning the social impacts of bowel/bladder dysfunction may also be considered not applicable due limited exposure to social events. Although these scales seem acceptable for the inpatient population based on the results of the Feasibility Survey for Participants, these results are based on the questions that were answered.

Since multiple questions were deemed not applicable by the participants, no definite conclusions can be made about the acceptability of the SCI-QOL v1.0 Bowel and Bladder Dysfunction Scales for those in inpatient settings. It is worth noting that three participants enrolled in outpatient rehabilitation provided comments that spoke to the applicability of these scales. One participant felt that the questions did not apply to individuals with indwelling catheters as they may not need to use restroom facilities in public spaces or complete bladder programs. Two other participants felt that the wording and ranking of the questions were not easily accessible and did not leave enough room for nuance, thereby failing to accurately capture their experiences with bladder/bowel management.

The SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales did not differentiate between active social engagement (e.g., playing sports, swimming) and non-active social engagement (e.g., watching movies, going to a restaurant). The two categories may be differently impacted by bladder/bowel dysfunction and types of bladder/bowel management. For example, non-active social engagement would not be as significantly

impacted by the presence of an indwelling catheter whereas swimming would be. Hence, the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales may also be not acceptable for outpatients as well as inpatients.

### 3.4.2 Implementation

Participants enrolled in inpatient rehabilitation expressed a dissatisfaction with the timing of the assessment. Inpatients felt that the evaluation came too late during their rehabilitation and failed to accurately report any meaningful bowel/bladder changes they experienced. This suggests that bowel and bladder function may undergo a rapid change during the rehabilitation process and timely assessment is essential. Given that the implementation process in this study did not reflect the clinical application of these scales, we cannot conclude that timing would be the only issue during the implementation process. However, these preliminary results still provide valuable information on how the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales should be implemented in the future, with focus on early assessment.

### 3.4.3 Limited Efficacy

In regard to the responses of the Feasibility Survey for Participants, the sub-domain of limited efficacy had the least amount of consensus on whether or not the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales contributed to limited efficacy. Given that a sample size calculation indicated that 85 participants would be needed to show detectable change, the low participant number in this study most likely contributed to weak correlation between the participant FIM<sup>TM</sup> scores and their summary scores on the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales summary scores. Although the Spinal Cord Independence Measure (SCIM) is thought to have better psychometric properties for the SCI population, the recruitment cite does not routinely collect the SCIM. Therefore, the FIM was used in its place as an independence measure. As the instrument may not be ideal for assessing independence in the SCI population, this may have contributed to low correlation between the FIM<sup>TM</sup> scores and the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales.

### 3.5 Limitations

There are several limitations that need to be addressed for this study and the final interpretation of the findings. The most prominent limitation was the small sample size. Due to the admission criteria for inpatient therapy, participants who were medically unstable, or did not have restorative potential were excluded. Participant selection was conducted by the physiotherapists (PTs) and therefore, only those patients deemed appropriate for the study by the PTs were approached for consent. Therefore, the findings of this study may not be easily generalizable to other individuals with SCI.

FIM™ scores were only obtained from inpatients as the FIM™ evaluation is not conducted in the outpatient program. It is worth noting, that given the implementation process during this study, limited efficacy could not be tested fully. Since the scales were administered at only one time point and without the involvement of a clinician, it was difficult to assess whether the scales had a positive effect on participants' goals and rehabilitation planning. Finally, this study also reflected only one facility and therefore its findings cannot be generalized to the rest of the SCI population.

### 3.6 Implications and Future Directions

The SCI-QOL v1.0 Bowel and Bladder Dysfunction Scales may not be feasible for inpatient evaluation, despite being developed with high involvement of people living with SCI. The scales were designed and tested with predominantly male, community-dwelling adults with SCI. Future studies should focus acquiring feedback on the SCI-QOL v1.0 Bowel and Bladder Dysfunction Scales from additional participants such as those in acute care settings, individuals with non-traumatic SCI, and those not currently engaged in physical rehabilitation. Through this process, instruments tailored specifically to meet the needs of these individuals can be developed. Multi-site studies will also be beneficial for determining the generalizability of the findings. Given that there was poor correlation between the participant FIM™ bowel/bladder management scores and the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales summary scores, the scales may not be accurately measuring the level of bowel/bladder management difficulties, however, future research



examining the relationship between independence and bowel/bladder management is needed. The Feasibility Survey for Participants was developed specifically for this study in accordance with the Bowen framework for conducting feasibility studies (Bowen et al., 2008). This was in part due to the limited amount of feasibility assessment instruments currently available. Working towards the development of standardized feasibility assessment instruments would be beneficial for future feasibility trials in the SCI population.

### 3.7 Conclusions

The SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were deemed mostly feasible by inpatients and outpatients. Participants felt that the scales were practical but did not reach consensus in whether the scales effectively contributed to limited efficacy. In addition, some inpatients and outpatients felt that some questions on the scales were not applicable for them and inpatients were not satisfied with the timing of the assessment. Additional research involving individuals with non-traumatic SCI and individuals participating in inpatient rehabilitation is needed to address unique concerns that may exist within these populations, as they were not well represented in the development of the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales.

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## 4 Discussion, Conclusion, and Future Directions

Results of the scoping review demonstrated there is limited evidence describing bowel and bladder improvements following locomotor training. Further research is needed to confirm these preliminary findings, as most of these conclusions were based on secondary analyses and anecdotal information. Evaluation of bowel and bladder changes following LT are usually conducted through physical measures such as urodynamics, rather than PROs (Herrity et al., 2016; Morrison et al., 2018; Spungen et al., 2014). The mechanisms responsible for these improvements are also unknown in both individuals with SCI and their able-bodied counterparts (Dainese et al., 2004; De Schryver et al., 2005) although Spungen and colleagues (2014) suggest that the activation of the abdominal musculature and, possibly, the action of ambulation itself may contribute to the stimulation of colonic motility. Hubscher and colleagues (2018) also propose that the potential impacts on bowel and bladder function may be due to afferent input associated with LT.

Improvements in bowel and bladder functioning can ultimately contribute to higher QOL in individuals living with SCI by reducing medication reliance, increasing independence, and improving bowel continence (Burns et al., 2015). Improved bowel and bladder continence can allow higher participation in recreational, social or therapeutic activities, or make it possible to secure full time employment. Urodynamics and other physical measures bowel and bladder function may fail to highlight the meaningful changes participants experience that fall outside the domain of physical changes (Nixon et al., 2018). Coincidentally, PROs are a tool that is focused on the patient's perspective and the impact a condition or intervention may have on their QOL, such as participation in social events and in public spaces (Nixon, Spackman, Clement, Verma, & Manns, 2018).

PROs can be used to accurately measure and record QOL impacts of bowel and bladder dysfunction (Tulsky et al., 2015). The SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were deemed mostly feasible by both inpatients and outpatients. The scales were regarded as practical, but no consensus was reached on whether the scales contributed to

limited efficacy. Within the sub-domain of implementation, participants felt unsatisfied with the timing of the assessment and felt that it was conducted too late during their rehabilitation stay. Additionally, numerous participants felt that certain questions from the SCI-QOLv1.0 Bowel and Bladder Dysfunction Scales were not applicable for them. The scales may need to be tailored to accommodate for bowel and bladder concerns and management difficulties that are experienced by individuals in different stages of the recovery process, where persons with SCI may have different concerns and level of impairment in acute care versus inpatient and outpatient rehabilitation settings. One of the reasons these scales may not be acceptable for inpatient use is a large section is devoted to public settings (i.e., public restrooms) and situations that an individual may not experience while enrolled in inpatient rehabilitation (e.g., social gatherings, sexual encounters, etc.). More attention should be devoted towards inpatient-specific concerns (e.g., interruption of physiotherapy sessions due to bowel or bladder accidents). Further investigation into the relationship between bowel and bladder function and locomotor training is needed. Recognizing that individuals in recent post-acute stages of SCI and those participating in rehabilitation may have different concerns than their community-dwelling counterparts should be a starting point to creating better, more accurate instruments to measure bowel and bladder function.

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# Appendices

## Appendix 1

### SCI-QOLv1.0 Bladder Complications Scale

SCI-QOL v1.0 – Scale – Bladder Complications

#### Bladder Complications – Scale

Please respond to each question or statement by marking one box per row.

Lately...		Never	Rarely	Sometimes	Often	Always
rTolQL_50 SCREENER ITEM	I had a urinary tract infection.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

In the past 7 days...		Not at All	A Little Bit	Somewhat	Quite a Bit	Very Much
rTolQL_21	A UTI (urinary tract infection) limited my daily activities.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rTolQL_26	I had an increase in spasms because of a UTI (urinary tract infection).	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

Lately...		Never	Rarely	Sometimes	Often	Always
rTolQL_74	I had a UTI (urinary tract infection) that would not go away.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rTolQL_Cat3	Bladder issues limited my sex life.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rTolQL_Cat4	I avoided going out because of my UTI (urinary tract infection).	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

## Appendix 2

## SCI-QOL v1.0 Bladder Management Difficulties Short Form

SCI-QOL v1.0 – Bladder Management Difficulties – Short Form 8a

**Bladder Management Difficulties – Short Form 8a**

Please respond to each question or statement by marking one box per row.

Lately...		Not at All	A Little Bit	Somewhat	Quite a Bit	Very Much
rToiletL_31	I was frustrated by bladder accidents.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rToiletL_5	I worried that I would have a bladder accident.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rToiletL_30	Bladder accidents limited my independence.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rToiletL_23	I was sad / depressed because of problems with bladder functioning.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rToiletL_16	I worried about performing my bladder program.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rToiletL_C02	I worried about performing my bladder program in a public restroom.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

Lately...		Never	Rarely	Sometimes	Often	Always
rToiletL_76	I had bladder accidents.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
rToiletL_72	Bladder accidents have disrupted my daily activities.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

## Appendix 3

## SCI-QOLv1.0 Bowel Management Difficulties Short Form

SCI-QOL v1.0 – Bowel Management Difficulties – Short Form 9a

**Bowel Management Difficulties – Short Form 9a**

Please respond to each question or statement by marking one box per row.

	<b>Lately...</b>	<b>Not at All</b>	<b>A Little Bit</b>	<b>Somewhat</b>	<b>Quite a Bit</b>	<b>Very Much</b>
r101e10_33	I was frustrated by repeated bowel accidents.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
r101e10_34	I worried that my social activities would be interrupted by a bowel accident.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
r101e10_27	I worried I would have a bowel accident.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
r101e10_4	Bowel accidents limited my independence.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
r101e10_7	A bowel accident has affected my self-esteem.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
r101e10_29	I was upset by problems with my bowel functioning.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
r101e10_12	I worried about performing my bowel program.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

	<b>Lately...</b>	<b>Never</b>	<b>Rarely</b>	<b>Sometimes</b>	<b>Often</b>	<b>Always</b>
r101e10_45	Bowel accidents have disrupted my daily activities.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
r101e10_52	I had bowel accidents.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

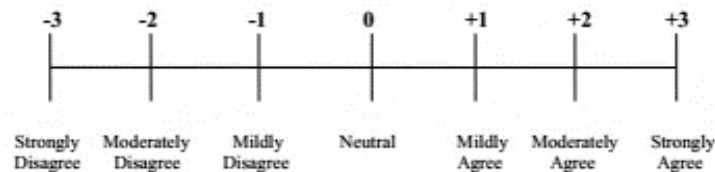
## Appendix 4

### Feasibility Survey for Participants

#### Feasibility Survey for Participants – Assessment Package – SCI-QOL Bowel and Bladder Dysfunction Scales

This survey asks you to reflect on the SCI-QOL Bowel and Bladder forms in terms of how feasible the protocol is to put in practice. The assessment package consists of:

1. SCI-QOL Bladder Complications Scale
2. SCI-QOL Bladder Management Difficulties Short Form
3. SCI-QOL Bowel Management Difficulties Short Form



Using the above scale, please indicate how strongly you agree or disagree with each of the following statements. Consider each of these statements by thinking about **the SCI-QOL Bowel and Bladder** assessments in general. If a particular question does not apply to you, enter N/A in the “0” or “Neutral” column):

ACCEPTABILITY	-3	-2	-1	0	+1	+2	+3	N/A
<i>Acceptability</i> refers to the extent that a new idea, program, process or measure is judged as suitable, satisfying, or attractive to program deliverers.								
You are fully satisfied with the <b>SCI-QOL Bowel and Bladder</b> assessments.								
You believe <b>SCI-QOL Bowel and Bladder</b> assessments were appropriate for you.								

IMPLEMENTATION	-3	-2	-1	0	+1	+2	+3	N/A
<i>Implementation</i> refers to the extent a new idea, program, process, or measure is successfully delivered to intended participants in some defined, but not fully controlled, context.								
You were provided sufficient resources (i.e., time, assistance) to complete <b>SCI-QOL Bowel and Bladder</b> assessments.								

<b>PRACTICALITY</b>	-3	-2	-1	0	+1	+2	+3	N/A
<i>Practicality refers to the extent that an idea, program, process, or measure can be carried out with intended participants using existing means, resources, and circumstances and without outside intervention.</i>								
The SCI-QOL Bowel and Bladder assessments were easy to complete. .								
The SCI-QOL Bowel and Bladder assessments were conducted efficiently, at the right time and with appropriate quality.								
The SCI-QOL Bowel and Bladder assessments had a positive effect on informing you of possible bowel and bladder changes you may be experiencing.								
You have sufficient ability (i.e., upper extremity function) to carry out the assessments in the packages.								

<b>LIMITED EFFICACY</b>	-3	-2	-1	0	+1	+2	+3	N/A
<i>Limited Efficacy refers to the degree that a new idea, program, process, or measure shows promise of being successful with the intended population, even in a highly controlled setting.</i>								
The SCI-QOL Bowel and Bladder assessments were appropriate to assess your bowel/bladder function.								
The SCI-QOL Bowel and Bladder assessments had positive effects on your rehabilitation goal setting.								
The SCI-QOL Bowel and Bladder assessments resulted in more meaningful interventions for you.								

If you disagreed with a question, please specify the specific items (i.e., a particular assessment) for which you disagree:

If you disagreed with a question, please specify the reason for the disagreement:

Appendix 5

Functional Independence Measure (FIM)

ACTIVITIES AND PARTICIPATION																									
<b>FIM® instrument</b>																									
	Admission																								
<b>Self-Care</b>																									
41. Eating	<input type="text"/>																								
42. Grooming	<input type="text"/>																								
43. Bathing	<input type="text"/>																								
44. Dressing — Upper Body	<input type="text"/>																								
45. Dressing — Lower Body	<input type="text"/>																								
46. Toileting	<input type="text"/>																								
<b>Sphincter</b>																									
47. Bladder Management	<input type="text"/>																								
48. Bowel Management	<input type="text"/>																								
<b>Transfers</b>																									
49. Bed, Chair, Wheelchair	<input type="text"/>																								
50. Toilet	<input type="text"/>																								
51. Tub, Shower	<input type="text"/>																								
<b>Locomotion</b>																									
52. Walk/Wheelchair	<input type="text"/> <div style="display: inline-block; vertical-align: middle; margin-left: 5px;"> <input type="radio"/> Walk  <input type="radio"/> Wheelchair  <input type="radio"/> Both                 </div>																								
53. Stairs	<input type="text"/>																								
<b>Communication</b>																									
54. Comprehension	<input type="text"/> <div style="display: inline-block; vertical-align: middle; margin-left: 5px;"> <input type="radio"/> Auditory  <input type="radio"/> Visual  <input type="radio"/> Both                 </div>																								
55. Expression	<input type="text"/> <div style="display: inline-block; vertical-align: middle; margin-left: 5px;"> <input type="radio"/> Vocal  <input type="radio"/> Non-Vocal  <input type="radio"/> Both                 </div>																								
<b>Social Cognition</b>																									
56. Social Interaction	<input type="text"/>																								
57. Problem-Solving	<input type="text"/>																								
58. Memory	<input type="text"/>																								
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This form was retrieved from the Rehabilitation Minimum Data Set Manual, Module 2 Clinical Coding and NRS Training (Coding, 2018).

## Appendix 6

### The Neurogenic Bowel Dysfunction score- NBD Score

Date: \_\_\_\_\_

#### The Neurogenic Bowel Dysfunction score – NBD Score<sup>1</sup>

1. How often do you defaecate?	Score
<input type="radio"/> Daily (score 0) <input type="radio"/> 2-6 times per week (score 1) <input type="radio"/> Less than once per week (score 6)	
<hr/>	
2. How much time do you spend on each defaecation?	
<input type="radio"/> Less than 30 min. (score 0) <input type="radio"/> 31-60 min. (score 3) <input type="radio"/> More than an hour (score 7)	
<hr/>	
3. Do you experience uneasiness, sweating or headaches during or after defaecation?	
<input type="radio"/> Yes (score 2) <input type="radio"/> No (score 0)	
<hr/>	
4. Do you take medication (tablets) to treat constipation?	
<input type="radio"/> Yes (score 2) <input type="radio"/> No (score 0)	
<hr/>	
5. Do you take medication (drops or liquid) to treat constipation?	
<input type="radio"/> Yes (score 2) <input type="radio"/> No (score 0)	
<hr/>	
6. How often do you use digital evacuation?	
<input type="radio"/> Less than once per week (score 0) <input type="radio"/> Once or more per week (score 6)	
<hr/>	
7. How often do you have involuntary defaecation?	
<input type="radio"/> Daily (score 13) <input type="radio"/> 1-6 times a week (score 7) <input type="radio"/> 3-4 times a month (score 6) <input type="radio"/> A few times a year or less (score 0)	
<hr/>	
8. Do you take medication to treat faecal incontinence?	
<input type="radio"/> Yes (score 4) <input type="radio"/> No (score 0)	
<hr/>	
9. Do you experience uncontrollable flatus?	
<input type="radio"/> Yes (score 2) <input type="radio"/> No (score 0)	
<hr/>	
10. Do you have peri-anal skin problems?	
<input type="radio"/> Yes (score 3) <input type="radio"/> No (score 0)	
<hr/>	
Total score (between 0 and 47)	
<hr/>	

#### General satisfaction

Please mark the scale with a cross (x) to represent your general satisfaction with your bowel management.  
(Total dissatisfaction = 0 / Perfect satisfaction = 10)

0 0  1  2  3  4  5  6  7  8  9  10

#### Severity of bowel dysfunction

Score 0-6: Very minor  
 Score 7-9: Minor  
 Score 10-13: Moderate  
 Score 14+: Severe

<sup>1</sup> Krogh K, Christensen P, Sabroe S, Laurberg S. Neurogenic bowel dysfunction score. Spinal Cord 2006;44:625-631



## Curriculum Vitae

**Name:** Anna Rudkovska

**Post-secondary  
Education and  
Degrees:** University of Toronto  
Toronto, Ontario, Canada  
2009-2013 B.Sc.

The University of Western Ontario  
London, Ontario, Canada  
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**Honors and  
Awards:** Global Benefits Post-Secondary Education Scholarship  
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3<sup>rd</sup> place  
2018

**Related Work  
Experience** Teaching Assistant  
University of Western Ontario  
2016

Teaching Assistant  
University of Western Ontario  
2017

Guest Lecturer (HS1002)

University of Western Ontario

2018

**Publications:**

Maskell, R., **Rudkovska, A.**, Kfrerer, M., & Sibbald, S. Collaborative Care Models for Integrating Mental Health and Primary Care: A Policy Overview. *University of Western Ontario Medical Journal*. 2017; 86(2)

Sui, W. & **Rudkovska, A.** (accepted, April 14, 2018). Stand up for your health: Excessive sedentary behaviour as a modifiable risk factor for chronic disease. *Health Science Inquiry*.

**Rudkovska, A.**, Sui, W., & Kfrerer, M. (accepted, April 25, 2018). Catheter re-use: Thrifty or threatening? A commentary on intermittent catheter re-use by individuals with spinal cord injury. *Health Science Inquiry*.