ADVANCING PHYSICAL ACTIVITY INTERVENTION MEASUREMENT AND DEVELOPMENT AMONG PEOPLE WITH SPINAL CORD INJURY: A BEHAVIOUR CHANGE SCIENCE AND INTEGRATED KNOWLEDGE TRANSLATION APPROACH

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submitted by Jasmin Ma in partial fulfillment of the requirements of

the degree of Doctor of Philosophy

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Abstract

The purpose of this dissertation was to advance physical activity (PA) intervention measurement and development among people with spinal cord injury (SCI) by 1) comparing the agreement and strengths and weaknesses of the two most commonly used PA measures for people with SCI; and 2) using both integrated knowledge translation (IKT) and behaviour change theory for intervention development. **Study 1** compared the use of accelerometers and the Physical Activity Recall Assessment for People with SCI for measuring PA in people with SCI. A qualitative analysis explored the strengths and weaknesses of each measure in capturing the different components of PA (i.e., frequency, intensity, time, and type). Findings suggested these measures may be best used concurrently and the results informed the PA measurement strategy used in study 3. **Study 2** described the process of developing an IKT and theory-based intervention for increasing PA among people with SCI. The IKT process involved 5 phases: i) a synthesis of the evidence base through two systematic reviews and a meta-analysis, ii) key informant interviews with people with SCI, iii) a national survey of physiotherapists, iv) an expert panel meeting to inform key intervention recommendations, and v) a pilot-test of the intervention among physiotherapists to assess its feasibility and efficacy of the intervention to increase factors that influence its implementation. The IKT process resulted in the selection of the Health Action Process Approach model as the intervention's theoretical framework and to organize the delivery of tailored strategies that related to the key themes of education, referral, and prescription. **Study 3** was a randomized controlled trial of the efficacy of the intervention to change PA behaviour, fitness, and psychosocial predictors of PA among people with SCI. Significant, medium to large sized effects were found on PA behaviour, psychosocial predictors of PA and fitness in the intervention group compared to control. Together, the dissertation studies highlight the

importance of refining intervention evaluation and development and provides an example process for doing so by combining behaviour change theory with IKT.

Lay Summary

The goals of this dissertation were to first, better understand the strengths and weaknesses of the most commonly used physical activity (PA) measures in people with spinal cord injury (SCI) and second, use behaviour change theory and the engagement of end-users throughout the research process to develop a PA intervention for people with SCI. Important results included 1) the recommendation to use both accelerometer and self-report measures for measuring PA in people with SCI, 2) the development of a theory-based intervention that leveraged strategies of education, referral, and prescription as recommended by end-users, and 3) the finding that a theory-based intervention that engaged end-users throughout the research process resulted in improvements in accelerometer and self-reported PA, psychosocial predictors of PA, and fitness. This work highlights the importance of refining intervention evaluation and development and provides an example process for doing so by combining behaviour change theory with end-user engaged research.

Preface

This thesis, presented in sandwich format, is based on the following three original manuscripts.

STUDY 1 (Chapter 2)
Jasmin K. Ma; Laura A. McCracken; Christine Voss; Franco H.N. Chan; Christopher R. West; and Kathleen A. Martin Ginis (In Press). Physical activity measurement in people with spinal cord injury: Comparison of accelerometry and self-report (the Physical Activity Recall Assessment for People with Spinal Cord Injury). *Disability and Rehabilitation.*
Ethics certificate #: H15-00852
Permission has been granted by Disability and Rehabilitation to reproduce this article.

Jasmin K. Ma's role in Study 1:

- Author of ethics application at UBC (H15-00852)
- Contributed to study design
- Lead investigator responsible for data collection, analysis and interpretation
- Primary author of manuscript

Role of co-authors in Study 1:

- KMG and CW conceived of/designed the study and obtained funding and assisted JM in obtaining ethics approval at UBC.
- LM assisted JM with data collection and analysis
- KMG, FC, and CV assisted JM with the analysis and interpretation of the data
- KMG, LM, CW, CV, and FC revised the article and approved of the final version of the manuscript before submission to *Disability and Rehabilitation.*

STUDY 2 (Chapter 3)
Jasmin K. Ma; Oren Cheifetz; Kendra R. Todd; Carole Chebaro; Sen Hoong Phang; Robert B. Shaw; Kyle J. Whaley; and Kathleen A. Martin Ginis. Development of a physiotherapist-led intervention to increase physical activity among people with spinal cord injury: An integrated knowledge translation and behaviour change science approach. *Submitted to Implementation Science.*
Ethics certificate #: H16-03004
Implementation Science allows the author to retain copyright and agrees to a Creative Commons license that allows the article to be used in accordance with the license.

Jasmin K. Ma's role in Study 2:

- Author of ethics application (H16-03004)
- Contributed to study design and measure selection
- Formed expert panel and hosted a one-day panel meeting
- Developed intervention based on evidence and expert panel recommendations
- Delivered intervention
- Lead investigator responsible for data collection, synthesis, analysis, and interpretation
- Primary author of manuscript

Role of co-authors in Study 2:

- KMG and OC contributed to study design, measure selection, and assisted JM with ethics application
- KMG and KT assisted JM in expert panel selection and meeting planning, administration and evaluation
- KMG obtained funding and assisted JM with the analysis and interpretation of the data
- KMG, OC, CC, SHP, RS, KW contributed expertise and recommendations to develop the intervention
- KMG, OC, KT, CC, SHP, RS, KW revised the article and approved of the final version of the manuscript before submission to *Implementation Science.*
- KT drafted a section of the manuscript and supplementary table

STUDY 3 (Chapter 4)

Jasmin K. Ma; Christopher R. West; and Kathleen A. Martin Ginis. Effects of education, referral, and prescription on physical activity, psychosocial predictors, and fitness in individuals with spinal cord injury: A randomized controlled trial.
Ethics certificate #: H17-00559

Jasmin K. Ma's role in Study 3:

- Author of ethics application
- Contributed to study design and measure selection
- Delivered intervention
- Lead investigator responsible for data collection, analysis, and interpretation
- Primary author of manuscript

R**ole of co-authors in Study 3:**

- KMG and CW conceived of/designed the study and obtained funding and assisted JM in obtaining ethics approval at UBC and McMaster.
- KMG and CW assisted JM with the analysis and interpretation of the data
- KMG and CW revised the article and approved of the final version of the manuscript before submission to *International Journal of Behavioural Nutrition and Physical Activity*

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List of Abbreviations

AGREE-II= Appraisal of Guidelines, Research, and Evaluation II

ANCOVA=Analysis of Covariance

ANOVA=Analysis of variance

BCT=Behaviour change technique

BCTT=Behaviour change technique taxonomy

FITT= Frequency, intensity, time type

HAPA= Health Action Process Approach

IKT=Integrated knowledge translation

KTA=Knowledge to Action

LTPAQ-SCI=Leisure Time Physical Activity Questionnaire for People with Spinal Cord Injury

MRC=Medical Research Council

MVPA= Moderate to vigorous physical activity

PA=Physical activity

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

RCT=Randomized controlled trial

SCI=Spinal cord injury

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The Department of Kinesiology, the School of Health and Exercise Sciences, and ICORD. No matter where I've been located the staff have been nothing short of the best. **Rebecca Clifford, Glenna Ciraolo, Adrienne Sinden, Jenn Rhodes, Nicole Carlos, Matt Sahl, Simon Liem, Lauralee Magtoto** you've all gone above and beyond and are part of the community that made Hamilton, Kelowna, and Vancouver feel like home. **Rob Shave**, I'm excited to see where HES is in 5, 10, 20 years from now. I have full confidence in your vision.

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Revved Up, Mac Wheelers, PACE, PARC, SCI BC, SCI Ontario, all my study participants, and community partners. You guys are the reason I do research. You've supported, inspired, and offered me your time and experiences. It is for you that I continue my mission to make physical activity possible for *everyone*.

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Dedication

To my family, Brandon, Catherine, and Bill, for always being honest, positive, and providing me with “the tools to succeed”.

Chapter 1: Introduction

1.1 Prevalence and incidence of spinal cord injury

It is estimated that there are 86 000 people living with spinal cord injury (SCI) in Canada with 4300 new cases of SCI each year (Noonan et al., 2012). Causes of spinal cord injury can be traumatic or non-traumatic (Noonan et al., 2012). Traumatic SCI occurs when physical impact damages the spinal cord (e.g., from a motor vehicle accident or a fall). Non-traumatic SCI is caused by a heath condition damaging the spinal cord (e.g., from disease or infection). The majority of individuals living with SCI are male (approximately 70%; Dryden et al., 2003), younger among people with traumatic SCI, and older among individuals with non-traumatic SCI (Noonan et al., 2012). Injuries are classified as resulting in quadriplegia when the injury is sustained at the cervical level and paraplegia when damage to the spinal cord injury is at the thoracic level or lower (Marino et al., 2003).

1.2 Regular physical activity participation among people with spinal cord injury

Regular physical activity (PA) participation among people with SCI offers a wide range of benefits spanning from improved physical and mental health to savings in health care costs. As examples, fitness and cardiometabolic health are improved following PA intervention (Gibbons, Stock, Andrews, Gall, & Shave, 2016; Nash, 2005; van der Scheer et al., 2017); there is a positive association between PA and quality of life (Tomasone, Wesch, Ginis, & Noreau, 2013) as well as subjective well-being and life satisfaction (Martin Ginis, Jetha, Mack, & Hetz, 2009); also, the risk of hospitalization is cut in half in the first year after injury for those who exercise at least two times per week (Dejong et al., 2013). Resultantly, it has been projected that being physically active equates to savings to the healthcare system of US$290,000 to US$435,000 over the lifetime of an individual with SCI (Miller & Herbert, 2016).

1.3 Benefits, barriers, and low levels of physical activity participation among people with spinal cord injury

Despite these benefits, there are many barriers that make participating in PA particularly challenging for people with SCI. Over 200 barriers to PA participation have been identified among people with physical disabilities (Martin Ginis, Ma, Latimer-Cheung, & Rimmer, 2016). Limited access to appropriate facilities and equipment, lack of knowledge of recreation personnel to work with individuals with disabilities, negative attitudes, cost, and transportation are just a small sample of the barriers to participating in PA (Fekete, Ph, Rauch, & Sc, 2012). Given the salient multi-level (i.e., inter/intra-individual, institutional, community, policy) barriers faced by people with physical disability (Martin Ginis et al., 2016), it is not surprising that PA participation rates among people with SCI are remarkably low. Indeed, participation in PA by people with SCI is low when compared to both able bodied and other populations with chronic disability (e.g., stroke, osteoarthritis, cerebral palsy; Van Den Berg-Emons, Bussmann, & Stam, 2010). A cross-sectional survey of almost 700 men and women with SCI demonstrated that 50% of respondents reported participating in no leisure time PA (i.e., activity that requires physical exertion and that one chooses to do in their free time (Bouchard & Shephard, 1994) whatsoever (Martin Ginis et al., 2010). Interventions are greatly needed to address the barriers to PA in order to increase levels of PA among people with SCI.

1.4 The current state of PA interventions among people with SCI and other physical disabilities

The definition of physical activity is any bodily movement that is produced by skeletal muscles and results in energy expenditure (Caspersen, Powell, & Christenson, 1985). Exercise is a subset of physical activity that is planned and is performed with the aim of improving some component of physical fitness (Caspersen et al., 1985). This dissertation focuses on the broader category of physical activity. A small number of systematic reviews have summarized the evidence for behavioural physical activity interventions. To provide an understanding of factors that promote intervention effectiveness, a qualitative meta-synthesis was conducted to explore participants' perceptions and experiences of PA interventions for adults with physical disability (Williams, Ma, & Martin Ginis, 2017). Ten articles were included in the review and thematic synthesis methods were used to generate overarching concepts. Results demonstrated that important interventions components included the perception of flexibility to an individual's needs, a sense of control over the intervention, an open and supportive environment, and the right type of communication (e.g., personally relevant, delivered in-person or over the internet by a health care provider). The potential for improved health (e.g., decreased medications, pain, and increased mobility, strength, function) and well-being (self-perceived happiness and life satisfaction; Ryan & Deci, 2001) and reframed thoughts about health and exercise such as exercise is fun, a priority, and rewarding, were identified by program participants as key intervention outcomes. Behaviour change strategies, gaining knowledge, and the need for social support were also identified as both influential intervention components and outcomes. These findings provide important directions for PA intervention development for people with disabilities, particularly the need to provide social support in tailored interventions that teach participants the self-regulation skills to maintain an active lifestyle.

Overall, interventions targeted towards people with physical disability have been modestly effective in changing PA behaviour. A meta-analysis of 24 randomized controlled trials of PA interventions in people with physical disability was conducted to examine the influence of theory, intervention characteristics, and behaviour change techniques (Ma & Martin

Ginis, 2018). Overall, PA interventions demonstrated small-medium sized effects on PA behaviour. However, interventions that were guided by behaviour change theory had medium-sized effects. Consistent with previous evidence (Hobbs et al., 2013; Michie, Abraham, Whittington, & Mcateer, 2009), none of the intervention characteristics (intervention provider, mode of delivery, setting) moderated intervention effectiveness. However, interventions that used the behaviour change technique 'self-monitoring of behaviour' resulted in significantly larger effects on PA than interventions that did not employ this technique, as did interventions that included feedback on behaviour, problem solving, and instructions on how to perform the behaviour. These findings support the use of theory and self-regulatory behaviour change techniques (e.g., self- monitoring, problem solving, feedback), but also suggest that more research is needed to understand the effective intervention characteristics (e.g., mode of delivery, intervention provider). The authors recommended the use of an integrated knowledge translation (IKT) approach to develop interventions that address the unique needs of individuals with disability.

A systematic review extended this meta-analysis and summarized the BCTs (irreducible, reproducible, and observable components responsible for eliciting changes in behaviour within an intervention; Michie et al., 2013) that have been used in PA self-management interventions specific to people with SCI (Tomasone et al., 2018). Thirty-one studies were included, 15 were prospective pre-post studies, 12 were RCTs, and four were quasi-experimental. Of the 16 experimental studies, half of them resulted in a significant improvement in PA or its antecedents (e.g., self-efficacy, intentions). It should be highlighted that the heterogeneity of outcomes and quality of studies precluded the use of meta-regression to draw firm conclusions regarding the most effective BCTs and intervention components. Nevertheless, a key finding was that BCTs related to self-management (e.g., instructions on how to perform the behaviour, goal setting, problem solving, action planning, and practical social support) had positive effects on PA. The authors highlighted that only 32 out of a possible 93 BCTs were used across the 31 studies, suggesting that the use of a broader range of BCTs remains to be explored.

In summary, reviews have been conducted on participant perspectives of effective intervention components (Williams et al., 2017) and the effectiveness of PA interventions among people with physical disabilities (Ma & Martin Ginis, 2018), as well as the behaviour change techniques used in PA self-management interventions among people with SCI (Tomasone et al., 2018). These reviews highlight the use of theory, self-regulatory strategies, providing knowledge, and tailoring to the individual. These are important *broad* directions for future intervention developers to follow in order to ensure that their resources are being used effectively; however, interventionists lack *specific* direction on how to optimally use theory and provide tailored self-regulatory strategies and knowledge in interventions.

1.5 Gaps/shortcomings in current PA interventions among people with SCI

A major shortcoming in complex interventions such as those in healthcare is that researchers do not fully define and develop interventions (Campbell et al., 2000; Eccles, Grimshaw, Walker, Johnston, & Pitts, 2005). At best, theory and a pilot-test is sometimes used to guide intervention development; however, engagement of end-users to assess intervention feasibility is rarely conducted. It has been suggested that interventions be rigorously evaluated before full-scale implementation, similar to the sequential phases of development before a drug can be used in practice (Campbell et al., 2000). Specifically, researchers should: i) identify evidence and theory that support the intervention's effectiveness; ii) choose intervention components through focus groups, surveys, or case studies; iii) define the optimum intervention and study design by conducting an exploratory trial to assess feasibility and acceptability among end-users and by pilot-testing outcome measures; iv) conduct a randomized controlled trial to assess efficacy; and finally v) launch full-scale, pragmatic implementation (Campbell et al., 2000; Eccles et al., 2005). To our knowledge, these steps have never been used to develop a PA intervention among people with disabilities.

Previous reviews have provided the broad directions for intervention development (e.g., use theory, self-regulatory strategies, tailoring; Ma & Martin Ginis, 2018; Tomasone et al., 2018). Using a phased and thorough development process such as that described above can help researchers to build upon these previous reviews' findings (Ma & Martin Ginis, 2018; Martin Ginis, Ma, Latimer-Cheung, & Rimmer, 2016; Tomasone et al., 2018) to refine and optimize an intervention before full-scale implementation. In doing so, we need to address two significant shortcomings or gaps in PA intervention development for people with SCI. First, there is a need to understand how best to measure PA performed by people with SCI in the community setting. Second, there is an absence of IKT used to rigorously develop PA interventions for people with SCI.

1.6 Gap #1: The need to understand how best to measure PA performed in the community setting

If we are to rigorously test interventions before implementing, we need good measures of PA for people with SCI in community intervention settings. The two most widely used PA measures in SCI research are accelerometers and the self-report PARA-SCI (Martin Ginis, Latimer, Hicks, & Craven, 2005; Martin Ginis & Latimer-Cheung, 2016). Support for the validity of accelerometers to measure PA among people with SCI has been shown across the community, laboratory, and hospital settings (Conger, Scott, Fitzhugh, Thompson, & Bassett, 2015; Warms & Belza, 2004; Zbogar, Eng, Miller, Krassioukov, & Verrier, 2016). Although accelerometers are often praised as providing more accurate measurement than self-report measures, there are limitations to the types of activity accelerometers can capture. For example, PA measurement may be inaccurate during wheeled activity on a slope (Conger et al., 2015; Kooijmans, Moremans, Stam, & Bussman, 2014), wheeling on rough, uneven surfaces (Collins et al., 2010), and during resistance or lifting activities (Bassett et al., 2000). Other methods may be needed to capture these activities.

The PARA-SCI is a comprehensive 3-day PA recall questionnaire guided by a structured interview (Martin Ginis & Latimer-Cheung, 2016). The PARA-SCI has been shown to be the best estimate of PA energy expenditure under free-living conditions when compared to other self-report and objective activity trackers, and when using doubly labelled water as the reference standard (Tanhoffer, Tanhoffer, Raymond, Hills, & Davis, 2012). However, the PARA-SCI also has inherent limitations including recall bias (Shephard, 1967), the possibility of participants misclassifying the perceived intensity of their activities (Brodin, Swardh, Biguet, & Opava, 2017; Martin Ginis, Latimer, Hicks, & Craven, 2005), and respondents' failure to recall brief or very light bouts of PA (Martin Ginis et al., 2005; Shephard, 2003).

The PARA-SCI might be able to overcome some of the limitations of accelerometers as it is sensitive to the increased intensity of activity during inclined wheeling or resistance activities. Likewise, accelerometers may overcome some of the limitations of the PARA-SCI with its second-by-second data collection that is sensitive to brief periods of rest and short bouts of activity. It is possible that a combination of both accelerometers and self-report measures may be the most accurate method of assessing PA in people with SCI.

Thesis Objective #1:

To compare PA data collected using accelerometers and the PARA-SCI in the community setting to determine each measure's strengths and weaknesses for measuring PA in people with SCI.

1.7 Gap # 2: The need for an integrated knowledge translation approach to develop PA interventions for people with SCI

The Canadian Institute for Health Research defines knowledge translation as "the exchange, synthesis and ethically-sound application of knowledge - within a complex system of interactions among researchers and users - to accelerate the capture of the benefits of research for Canadians through improved health, more effective services and products, and a strengthened health care system." (http://www.cihr-irsc.gc.ca/e/29418.html, accessed Aug 23, 2018). Graham et al. (2006) developed the knowledge to action framework (KTA) to elucidate the research processes necessary for knowledge translation. By using these processes as a blueprint of stages in which end-users can be involved in research, the KTA can provide a framework-based approach to integrated knowledge translation (IKT; (Camden et al., 2015).

IKT is similar to community-based participatory research in that the emphasis is on creating partnerships between researchers and those who the research is intended for. However, IKT focuses on the application of knowledge rather than the use of research to address social injustices (Jull, Giles, & Graham, 2017). Specifically, IKT is the involvement of end-users throughout the entire research process (Strauss, Tetroe, & Graham, 2013). This involvement includes the engagement of end-users in the development or refinement of the research question, selection of methodology, data collection and tool development, outcome measure selection, interpretations of findings, crafting recommendations, and dissemination and implementation of the results (Strauss et al., 2013). It has been recommended that researchers should understand the specific needs of both knowledge users and interventionists (Graham et al., 2006). This understanding should include acknowledgement of barriers and facilitators to intervention use and uptake, and corresponding strategies that address these factors (Graham et al., 2006).

Given the numerous barriers to PA participation faced by people with SCI (Fekete et al., 2012) and challenges to PA promotion faced by interventionists (Ma, Cheifetz, Todd, Chebaro, Phang, Shaw, Whaley, & Martin Ginis, 2018), the involvement of end-users may be particularly important to intervention development for this population. Recommendations from the most recent systematic review of PA interventions among people with SCI emphasized the need to understand the factors that influence intervention success and ultimately ensure the translation of this knowledge into practice (Tomasone et al., 2018). The need to ensure knowledge translation into practice may be addressed through IKT. Indeed, the involvement of end-users has been shown to be the best predictor of the translation of research into practice (Curran, Mukherjee, Allee, & Owen, 2008). The need to understand what factors influence intervention success may be addressed through the use of behaviour change theory to design and test interventions.

Theories explain behaviours in a logical, parsimonious, coherent, and comprehensive manner using mutually-exclusive and clearly-defined constructs (Brawley, 1993; Graham, Tetroe, & the KT Theories Research Group, 2007; Michie, West, & Spring, 2013). Using theory to develop interventions is important for many reasons: using theory can help identify mechanisms of change, or in other words, the factors that influence intervention success (Michie, Johnston, Francis, Hardeman, & Eccles, 2008); theory provides a framework to develop an understanding of what constructs work across different populations, contexts, and behaviours; and interventions that are developed using theory have tended to demonstrate larger effects on

PA behaviour than interventions that do not use theory (Ma & Martin Ginis, 2018; Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Webb, Joseph, Yardley, Michie, & Webb, 2010). Examples of theories that resulted in successful PA interventions in people with SCI include the Health Action Process Approach (HAPA) model (Arbour-Nicitopoulos, Martin Ginis, & Latimer, 2009; Latimer, Martin Ginis, & Arbour, 2006; Schwarzer, 2008), the transtheoretical model (Nooijen et al., 2016; Prochaska & DiClemente, 2005), and social cognitive theory (Bandura, 1986; Froehlich-Grobe et al., 2012, 2014).

1.7.1 Limitations of using IKT or behaviour change theory individually.

Using IKT without behaviour change theory to develop interventions has its limitations. Partnering with end-users can strengthen knowledge of barriers to, and strategies for, changing behaviour (Graham et al., 2006); however, knowledge alone is insufficient for behaviour change (Conn, Hafdahl, Brown, & Brown, 2008; Ferris, Gunten, & Emanuel, 2001). IKT on its own does not tell us how addressing barriers and developing strategies lead to behaviour change.

On the one hand, using theory can fill this gap by providing a framework of constructs that can be targeted through behaviour change strategies and by describing how changing these constructs can lead to behaviour change (Michie & Prestwich, 2010). For example, in a systematic review of factors that affect PA participation in people with SCI, facilitators included having the self-efficacy to participate in PA, receiving support from family members, and goal setting, whereas barriers included lack of knowledge and fear of injury (Fekete et al., 2012). Behaviour change theories could be used to organize these facilitators to understand which constructs to target for behaviour change. For instance, the HAPA model (Schwarzer, 2008) posits that addressing risk perceptions and increasing task self-efficacy would help develop intentions to participate for those who are not motivated to exercise; developing action plans would aid in translating intentions into action; and that providing resources such as social support and knowledge is beneficial for developing intentions as well as maintaining the behaviour (Schwarzer, 2008).

On the other hand, theory does not provide a framework for how to work with your end-users to understand factors (i.e., barriers and facilitators) that affect participation. Furthermore, rarely do theories highlight *how* constructs should be targeted through specific strategies. Therefore, using behaviour change strategies without IKT is not ideal. IKT frameworks can provide a blueprint for engaging end-users throughout the research process to better understand the context in which the intervention is to be implemented. For example, the Knowledge to Action (KTA) framework assumes an ongoing collaboration between researchers and end-users to contextualize knowledge (Graham et al., 2006). The KTA outlines the different phases of research that can be informed by end-user collaboration such as problem refinement, intervention development, dissemination, uptake, and monitoring while highlighting the importance of considering the local context and barriers (Graham et al., 2006). In summary, the combination of IKT and behaviour change theory is ideal for intervention development.

Several authors have suggested that IKT and behaviour change theory may be an appropriate combined approach to intervention development. Implementation experts have highlighted i) the use of theories to guide intervention development and data collection plans, ii) the need for formative evaluation processes to understand local barriers and facilitators to adoption, and iii) the development of partnerships with interventionists to maximize the potential fit of interventions (Curran et al., 2008)**.** Likewise, in its guidelines for complex intervention development (Craig, Dieppe, Macintyre, Michie, & Nazareth, 2008), the Medical Research Council recommends drawing on existing evidence and theory to develop an understanding of how [behaviour] change will occur and acknowledges that interventions may work best if they are tailored to the local context rather than being standardized to a rigid template (Craig et al., 2008). These recommendations provide a strong rationale for employing both behaviour change theory and IKT when developing PA interventions.

In summary, theories identify *which* constructs to target, while the IKT process can determine *how* a construct is targeted when researchers work with end-users to inform the strategies that lead to intervention success. Currently, there is no established consensus on optimal methods for intervention development; however, exploration of new methods and approaches is encouraged (Curran et al., 2008). Approaches that integrate behavior change theory and IKT have been identified as promising.

Thesis Objective #2:

To develop a PA intervention for people with SCI using a process that integrates both an IKT process and behaviour change theory.

1.8 Dissertation overview

The overall purpose of this dissertation was to advance PA measurement and intervention development in people with SCI by 1) comparing the agreement, strengths and weaknesses of the most commonly used PA measures in SCI research, accelerometers and the PARA-SCI; and 2) developing an intervention using both IKT and behaviour change theory. To accomplish this purpose, three studies were conducted. **Study 1** compared the use of accelerometers and a self-report measure (the PARA-SCI) for measuring wheeled and non-wheeled, total and moderate-vigorous physical activity in community-dwelling people with SCI. A qualitative analysis was also undertaken to explore the strengths and weaknesses of each measure for capturing the different components of physical activity (i.e., frequency, intensity, time, and type). These results informed the selection of PA measures in study 3. **Study 2** was a series of projects to develop an IKT and theory-based intervention for increasing PA among people with SCI. The process involved 5 phases: i) synthesis of two systematic reviews and a meta-analysis, ii) completion of key informant interviews with people with SCI, iii) conduct of a national survey of physiotherapists, iv) use of an expert panel to inform key intervention recommendations, and v) a pilot-test of the intervention among physiotherapists to assess feasibility and ability of the intervention to modify factors that influence its implementation. **Study 3** was a randomized controlled trial of the efficacy of the intervention to change PA behaviour, fitness, and psychosocial predictors of PA among people with SCI. These studies are presented in the subsequent dissertation chapters.

Chapter 2: Physical activity measurement in people with spinal cord injury: Comparison of accelerometry and self-report (the Physical Activity Recall Assessment for People with Spinal Cord Injury)

2.1 Background

Fitness and cardiometabolic health have shown significant improvements following physical activity interventions in people with spinal cord injury (SCI) (Gibbons et al., 2016; Nash, 2005; van der Scheer et al., 2017). An essential component to accurately evaluate the impact of these physical activity interventions on fitness and health outcomes is the use of valid and comprehensive measures of physical activity. Good measures of physical activity are needed for several reasons: accurate measurement of frequency, intensity, time, and type is needed to elucidate the dose-response relationship between physical activity and optimal health outcomes (Prince et al., 2008), precise assessments of baseline levels of physical activity to aid in the development of appropriately tailored exercise prescriptions in interventions [4], and confidence in the validity of research results is increased (Warms, Belza, Whitney, Mitchell, & Stiens, 2007). Overall, both clinical and research applications benefit from the use of accurate physical activity measures.

In recent years, the Physical Activity Recall Assessment for People with Spinal Cord Injury (Martin Ginis & Latimer-Cheung, 2016; Martin Ginis, Latimer, Hicks, & Craven, 2005; a comprehensive 3-day physical activity recall questionnaire guided by a structured interview) and accelerometers have been the two most widely used physical activity measures in SCI research (Arbour-Nicitopoulos, Martin Ginis, & Latimer, 2009; Latimer, Martin Ginis, & Arbour, 2006; Nooijen et al., 2016). Indeed, numerous validation studies have supported the appropriateness of their use in the SCI population. For example, criterion and convergent validity of the Physical Activity Recall Assessment for People with SCI have been demonstrated using indirect calorimetry and measures of strength and aerobic fitness, respectively (Latimer, Martin Ginis, Craven, & Hicks, 2006; Martin Ginis et al., 2005). Additionally, Tanhoffer *et al.* (2012) assessed a range of self-report tools and objective trackers against energy expenditure measured via doubly labelled water- the reference standard to assess energy expenditure under free living conditions (Schoeller & van Santen, 1982)- and found that the Physical Activity Recall Assessment for People with SCI performed best.

Accelerometers have been validated across a number of settings for measuring physical activity among people with SCI. In a sample of community-dwelling people with SCI, Warms *et al.* (Warms & Belza, 2004) showed accelerometer counts increased with greater levels of self-reported physical activity intensity during activities conducted in the free-living environment. In a lab setting, Conger *et al.* (Conger et al., 2015) compared wrist accelerometers to indirect calorimetry in manual wheelchair users and demonstrated similar energy expenditure predictions based on the two measures. In a hospital setting, Zbogar *et al.* (2016) demonstrated a high correlation between accelerometer-measured physical activity and functional independence and grip strength in a sample of SCI in-patients. Thus, evidence of the validity of accelerometers has been demonstrated for SCI research in the community, laboratory, and hospital settings.

Despite evidence supporting the validity of the Physical Activity Recall Assessment for People with SCI and accelerometers in SCI research, questions remain. First, the agreement between Physical Activity Recall Assessment for People with SCI- and accelerometer-derived measures of physical activity in the community dwelling setting is not known. Zbogar *et al.* (2016) found wide limits of agreement and no relationship between Physical Activity Recall Assessment for People with SCI and accelerometer measures of physical activity; however, given the focus on in-patients in their study, it is unclear whether these findings extend to physical activity performed in the community. Second, the ability to measure moderate-vigorous physical activity, which is known to be most important for improving cardiometabolic health (van der Scheer et al., 2017), has not been compared between the Physical Activity Recall Assessment for People with SCI and accelerometers; previous studies only compared *total* physical activity (Tanhoffer et al., 2012; Zbogar et al., 2016). Further, neither of the aforementioned studies used individually calibrated accelerometer cut-points for determining physical activity intensity. Able-bodied group cut-points are largely inappropriate for the SCI population considering the individual differences in energy expenditure for a given workload resulting from varying levels of function (Jacobs & Nash, 2004). Indeed, our group recently compared the use of group and individual cut-points to interpret physical activity performed in the free-living environment and concluded that if cut-points are not individually determined for study participants, then derived moderate-vigorous physical activity may be largely inaccurate (McCracken, Ma, Voss, Chan, Ginis, et al., 2018). Third, it is unknown which physical activity components (i.e., frequency, intensity, time, and type) each measure is best suited to capture (Zbogar et al., 2016). This is the first study to explore the individual strengths and weaknesses of each measure to capture the different components of physical activity among people with SCI. These findings are intended to compare and contrast the two most widely used PA measures for people with SCI to better understand how to more accurately measure PA in this population.

Given these apparent gaps in our knowledge regarding physical activity in SCI, the purpose of this study was to (i) evaluate the level of agreement between individually calibrated accelerometers and the Physical Activity Recall Assessment for People with SCI when assessing total, wheeled, and non-wheeled moderate-vigorous physical activity in the community setting; and (ii) qualitatively examine how each measure captures different aspects of physical activity.

2.2 Materials and methods

Participants

Community-dwelling people with SCI were recruited from the greater Vancouver, Canada area. Participants were recruited through poster advertisements, at community events, and by contacting participants from previous studies who had given consent to be contacted for future studies. Inclusion criteria were: (a) chronic SCI (>1yr), and (b) 18-65 years of age. Exclusion criteria were: (a) an active stage 3 or 4 pressure ulcer; (b) any unstable medical/psychiatric condition that would affect ability to complete the study; (c) lack of proficiency in the English language that would prevent ability to follow instructions.

A sample size of 15 was needed to yield a significant *r* of .65 (Tanhoffer et al., 2012), using a one-tailed test, with $\beta = .80$ and $\alpha = .05$ (Faul, Erdfelder, Lang, & Buchner, 2007). As this study was part of a larger study (McCracken, Ma, Voss, Chan, Ginis, et al., 2018), a total of 22 participants were recruited. Each participant provided written informed consent. Ethics approval for the protocol was granted by the University of British Columbia Clinical Research Ethics Board.

Measures

Physical Activity Recall Assessment for People with Spinal Cord Injury

The Physical Activity Recall Assessment for People with SCI (Martin Ginis et al., 2005) is a physical activity recall measure whereby participants are asked to recall, in detail, their activity over the past three days (Appendix A). The interviewer recorded the intensity (mild, moderate, heavy), duration (minutes), activity type (e.g. wheeling, cleaning, resistance activity, wheelchair rugby), and classified each activity as leisure time physical activity or an activity of daily living (ADL). Supporting the reliability of the interview administration, the interviewer (JM) was trained by the developer of the Physical Activity Recall Assessment for People with

SCI (KMG) and followed the standardized, structured Physical Activity Recall Assessment for People with SCI interview protocol (Martin Ginis & Latimer-Cheung, 2016).

Wrist and spoke accelerometer

Participants were fitted with a wrist-worn accelerometer [GT9X link, ActiGraph, LLC, Pensacola, FL; 30 Hz] on the non-dominant hand as per recommendations from a previous study of optimal accelerometer placement in manual wheelchair users (Nightingale, Rouse, Thompson, & Bilzon, 2017). The non-dominant hand was identified as the hand that they would not typically use for completing activities of daily living (e.g. feeding, brushing, opening container, etc.). Participants were instructed to wear the accelerometer during all waking hours, except during bathing, swimming, and sleeping. To be included in analyses, participants were required to wear the accelerometer at least 10 hours on at least two of the three days recalled on the Physical Activity Recall Assessment for People with SCI (Troiano et al., 2007). The spoke accelerometer [USB Accelerometer X16-1D, Gulf Coast Data Concepts, LLC, Waveland, MS] was attached to a spoke on each wheelchair used by the participant.

Procedure

On the first day of data collection, participants completed a graded treadmill wheeling test while wearing the accelerometer to establish each participant's moderate-vigorous physical activity accelerometer cut-point. The full protocol has been described previously (Mccracken, 2018). In brief, energy expenditure was measured using indirect calorimetry and moderate-vigorous physical activity cut-points were defined as the vector magnitude corresponding to 3 SCI METs (the minimum accelerometer counts required to qualify as moderate intensity physical activity). Participants were instructed to wear the wrist accelerometer and use a spoke accelerometer for the next 6 days. Participants returned to the lab after the 6 days and completed the Physical Activity Recall Assessment for People with SCI with reference to the final 3 days of their monitoring period.

Data Analyses

Minutes of total, wheeled, and non-wheeled moderate-vigorous physical activity were extracted from the accelerometer and Physical Activity Recall Assessment for People with SCI data. Vector magnitude counts, which consider the magnitude of acceleration from three axes, were used for all accelerometer calculations. Total daily moderate-vigorous physical activity was calculated using ActiLife 6.0 software by applying the individually calibrated cut-points for moderate-vigorous physical activity. We have reported these methods elsewhere (McCracken, 2018). Using 1-second epochs, the number of accelerometer-counted bouts of continuous moderate-vigorous physical activity for 10-, 5-, and 1-minute bins were calculated to understand behavioural patterns. Tolerance levels (the greatest allowable time for counts to be measured below the moderate-vigorous physical activity threshold) of 2-minutes, 1-minute, and 20-seconds were used for the 10-, 5-, and 1-minute bouts, respectively. Calculation of the wheeled and non-wheeled activity has been previously described (McCracken, 2018). Moderate-vigorous physical activity values were averaged across the 3 days. Three participants were excluded from wheeled moderate-vigorous physical activity analyses due to technological malfunction with the spoke accelerometer.

Statistical Analyses

To assess agreement between Physical Activity Recall Assessment for People with SCI- and accelerometer-measured total moderate-vigorous physical activity, Bland-Altman plots with 95% limits of agreement were created (Bland & Altman, 1986).

Qualitative Analysis

To examine how each measure captures different aspects of physical activity, a qualitative analysis of the patterns of activity types, bouts, and accelerometer and Physical Activity Recall Assessment for People with SCI moderate-vigorous physical activity values was conducted. Moderate-vigorous physical activity types (e.g. basketball, wheeling, cleaning, etc.) were extracted from the Physical Activity Recall Assessment for People with SCI and categorized as "intermittent sport or leisure activities" (bursts of activity interspersed with periods of rest, e.g. rugby, ping pong), "activities of daily living" (e.g. cooking, cleaning), "wheeling" (inclined or uneven surface), "resistance activities" (activities that build strength), or "other". These activity types and total moderate-vigorous physical activity measured by accelerometer and the Physical Activity Recall Assessment for People with SCI were examined for patterns where the accelerometer consistently showed moderate-vigorous physical activity values that were different from the Physical Activity Recall Assessment for People with SCI. Specifically, discrepancies between the measures (i.e. differences greater than the Bland-Altman calculated bias for total physical activity) were identified and counted (Table 1). Accelerometer-measured bouts of continuous activity were also examined to understand how activity duration may play a factor in explaining discrepancies between the two measures.

2.3 Results

Of the 22 recruited participants, one participant was excluded for not having sufficient treadmill wheeling data (≥3 different stages) to calculate a moderate-vigorous physical activity cut-point. One participant was excluded for not meeting the minimum accelerometer wear time criteria (≥10 hours/day) and another was excluded for not completing the Physical Activity Recall Assessment for People with SCI due to scheduling conflicts. Thus, a final sample of 19 participants (3 women) were included in the total physical activity analyses. Three participants had insufficient wheeling data due to technological malfunction, thus 16 participants were included in the wheeled physical activity analyses. Participants were on average 43±11.2 years old, 19.0±12.9 years post injury, and had injury levels ranging from C5-L2. For each participant, individual cut-points for moderate-vigorous physical activity are reported elsewhere (McCracken, 2018). The average group cut-point for moderate to vigorous physical activity was 11652 (CI 7395 – 15909) vector magnitude counts/minute.

Level of agreement between PA data from the accelerometer and the Physical Activity Recall Assessment for People with Spinal Cord Injury

At the individual level, Bland-Altman plots of total moderate-vigorous physical activity revealed a bias of -5.6 min/day±70.41, with wide 95% limits of agreement (-143.6-132.4min/day; Figure 1, panel A). Bland-Altman plots of wheeled moderate-vigorous physical activity showed a bias of -9.7±30.2min/day, with 95% limits of agreement (-69.0-49.5min/day; Figure 1, panel B). Non-wheeled moderate-vigorous physical activity Bland-Altman plots showed a bias of 12.3±53.8min/day, with 95% limits of agreement (-93.1-117.6min/day; Figure 1, panel C).

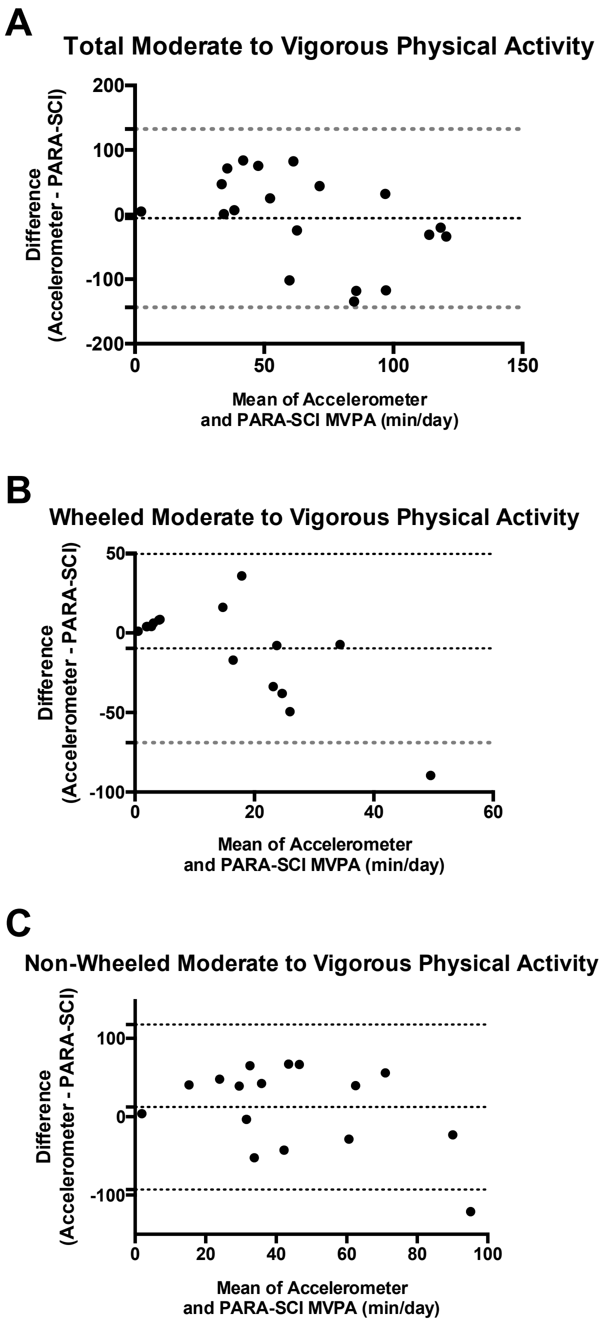

Figure 1. Study 1: Bland Altman plots of accelerometer and PARA-SCI measured physical activity.

Note. Panel A=total moderate-vigorous physical activity, Panel B=wheeled moderate-vigorous physical activity, Panel C= non-wheeled moderate-vigorous physical activity (panel C). Dotted lines represent 95% limits of agreement.

Qualitative analysis of differences in accelerometer- and Physical Activity Recall Assessment for People with Spinal Cord Injury-derived moderate-vigorous physical activity values

Patterns for each activity category were observed between accelerometer- and Physical Activity Recall Assessment for People with SCI-derived moderate-vigorous physical activity values (see Table 1 for individual participant data):

Intermittent sport or leisure activities: Except for two participants, on days where intermittent sport and leisure activities were reported on the Physical Activity Recall Assessment for People with SCI, moderate-vigorous physical activity measured by the accelerometer was lower than the Physical Activity Recall Assessment for People with SCI-measured moderate-vigorous physical activity. Analysis of bout durations from the accelerometer revealed these activities were conducted in very brief bouts (i.e., <1 minute).

Activities of daily living: On days where prolonged bouts of activities of daily living (e.g. bowel and bladder care, preparing food, driving) were reported, Physical Activity Recall Assessment for People with SCI-measured moderate-vigorous physical activity values were consistently higher than when measured by the accelerometer.

Inclined or uneven surface wheeling: Days that included wheeling on an incline showed accelerometer wheeled moderate-vigorous physical activity duration was consistently lower compared to the Physical Activity Recall Assessment for People with SCI values. The same pattern was found for wheeling on uneven surfaces (e.g., sand, gravel).

Resistance activities: Accelerometer and Physical Activity Recall Assessment for People with SCI total moderate-vigorous physical activity values were similar on days where resistance exercises using body weight were performed, but patterns were mixed when resistance exercises were externally loaded (e.g. use of machines, weights). Participants who performed activities of daily living such as lifting or moving objects reported greater Physical Activity Recall Assessment for People with SCI total moderate-vigorous physical activity values than those measured by the accelerometer.

Short bouts of activity: Short bouts of moderate-vigorous physical activity were typically under-reported on the Physical Activity Recall Assessment for People with SCI compared to accelerometers. Most bouts were completed in 1-minute durations. However, in most cases, the total of 10-, 5-, and 1-minute accelerometer bouts did not equate to total accelerometer moderate-vigorous physical activity meaning much of the activity was accumulated in bouts of <1-minute.

Table 1. Study 1: Physical Activity Recall Assessment for People with Spinal Cord Injury and accelerometer reported moderate to vigorous physical activity duration, bouts, and types for each participant

Injury	Gender	Accel total MVPA (min/day)	PARA-SCI total MVPA (min/day)	Accel wheeled MVPA (min/day)	PARA-SCI wheeled MVPA (min/day)	Accel non-wheeled MVPA (min/day)	PARA-SCI non-wheeled MVPA (min/day)	# of 10-minute bouts	# of 5-minute bouts	# of 1-minute bouts	Types of MVPA reported on PARA-SCI*
P	M	56	102	4	2	52	100	0	0	2	ISLA
		27	0	3	0	24	0	0	0	0	
		21	0	8	0	13	0	0	0	1	
T	M	109	20	14	0	95	20	5	0	23	Resistance activities (body weight)
		77	20	20	20	57	0	1	0	18	Wheeling
		122	10	34	0	88	10	0	0	6	Resistance activities (body weight)
P	M	101	140			101	140	2	6	19	Wheeling, resistance activities, other
		109	145			109	145	0	1	45	ISLA, wheeling, other
		115	100			115	100	0	0	20	ISLA
P	M	48	45	5	0	43	45	0	0	5	Resistance activities (body weight)
		38	2	3	0	35	2	0	0	0	ADL
		29	420	4	0	25	420	0	0	0	ADL
T	F	16	335			16		0	0	0	ADL
		20	92			20		0	0	0	ADL, resistance activities, wheeling
		16	152			16		0	0	0	ADL, wheeling, ISLA
P	F	60	30	8	0	52	30	1	2	0	Wheeling, resistance activities
		72	0	11	0	61	0	0	0	0	
		39	0	6	0	33	0	0	0	0	
T	M	48	0	8	0	40	0	0	0	47	
		61	105	9	60	52	45	1	1	45	Inclined wheeling
		17	0	2	0	15	0	0	0	26	

Injury	Gender	Accel total MVPA (min/day)	PARA-SCI total MVPA (min/day)	Accel wheeled MVPA (min/day)	PARA-SCI wheeled MVPA (min/day)	Accel non-wheeled MVPA (min/day)	PARA-SCI non-wheeled MVPA (min/day)	# of 10-minute bouts	# of 5-minute bouts	# of 1-minute bouts	Types of MVPA reported on PARA-SCI*
T	M	14	140	1	60	13	80	0	1	5	Inclined wheeling, other
		3	82	1	32	2	50	0	0	0	Inclined wheeling, wheeling
		9	110	2	60	7	50	0	0	0	Inclined wheeling, wheeling
P	M	172	213	2	148	170	65	8	19	65	ADL, uneven surface wheeling, wheeling
		94	102	11	100	83	2	4	8	19	Uneven surface wheeling
		45	97	1	35	44	62	3	6	13	ADL, uneven surface wheeling
P	M	105	0	9	0	96	0	1	1	11	
		30	0	2	0	28	0	0	0	0	
		79	0	7	0	72	0	0	0	19	
P	M	81	0	39	0	42	0	0	0	10	
		71	0	27	0	44	0	0	0	1	
		99	0	41	0	58	0	0	0	0	
T	M	123	66			123		0	1	53	ISLA, wheeling
		100	62			100		2	3	31	Wheeling, resistance activities
		58	20			58		0	0	14	Wheeling
T	M	126	141	35	56	91	85	0	0	39	Resistance activities, wheeling
		100	20	26	20	74	0	0	0	16	Wheeling
P	F	1	0	0	0	1	0	0	0	0	
		7	0	1	0	6	0	0	0	1	
		6	0	1	0	5	0	0	0	0	
P	F	33	0	5	0	28	0	0	0	0	
		44	185	4	0	40	185	0	0	0	ISLA
		74	150	4	0	70	150	0	0	2	ISLA
T	M	99	45	14	45	85	0	2	4	23	Wheeling
		52	44	5	5	47	39	0	0	4	Resistance activities, wheeling
		45	30	4	25	41	5	0	0	6	Other, wheeling

Injury	Gender	Accel total MVPA (min/day)	PARA-SCI total MVPA (min/day)	Accel wheeled MVPA (min/day)	PARA-SCI wheeled MVPA (min/day)	Accel non-wheeled MVPA (min/day)	PARA-SCI non-wheeled MVPA (min/day)	# of 10-minute bouts	# of 5-minute bouts	# of 1-minute bouts	Types of MVPA reported on PARA-SCI*
P	M	49	126	29	40	20	86	0	0	5	ADL (lifting)
		103	212	18	10	85	202	0	1	23	ISLA
		143	50	12	33	131	17	0	0	10	Uneven surface wheeling, ISLA
T	M	21	190	5	120	16	70	0	0	0	ADL (lifting), inclined wheeling
		37	239	6	10	31	229	0	0	0	ISLA, ADL (lifting)
		22	5	6	1	16	4	0	0	0	ADL
P	M	67	10	8	0	59	10	0	0	4	ADL
		75	10	6	0	69	10	0	0	6	ADL
		115	10	12	0	103	10	0	0	7	ADL

Note: Note. Accel= accelerometer, MVPA= moderate to vigorous physical activity, P=Paraplegia, PARA-SCI=Physical Activity Recall Assessment for People with Spinal Cord Injury, T= tetraplegia, M= male, F= female, ADL= activities of daily living, ISLA= intermittent sport or leisure activity. *Activity types are listed in order of greatest to lowest duration.

2.4 Discussion

The purpose of this study was to compare the agreement of moderate-vigorous physical activity between accelerometry and the self-reported Physical Activity Recall Assessment for People with SCI measures, and provide a qualitative examination of the different aspects of physical activity each measure captures. At the individual level, all categories of moderate-vigorous physical activity showed poor agreement when comparing accelerometers and the Physical Activity Recall Assessment for People with SCI. Qualitative analysis of differences in accelerometer and Physical Activity Recall Assessment for People with SCI data across different activity types suggest both the accelerometer and Physical Activity Recall Assessment for People with SCI capture types of physical activity that the other measure does not capture.

Level of agreement and relationship between accelerometer and Physical Activity Recall Assessment for People with Spinal Cord Injury data

At the individual level, poor agreement between the Physical Activity Recall Assessment for People with SCI and accelerometers was found which is consistent with previous research conducted in the in-patient rehabilitation setting (Zbogar et al., 2016). Zbogar et al. (2016) suggested that the discrepancy between accelerometer and Physical Activity Recall Assessment for People with SCI estimates of total moderate-vigorous physical activity was likely a result of the measures capturing different components of physical activity. Specifically, the activities performed in the rehabilitation setting may have been too slow to be picked up by the accelerometer but were identified in the Physical Activity Recall Assessment for People with SCI or some activities may have been too brief for a participant to consider them moderate-vigorous physical activity. Likewise, the poor agreement observed in the present study does not question the validity of either the Physical Activity Recall Assessment for People with SCI or accelerometer, rather these measures likely capture different aspects of physical activity in the community-dwelling setting as well. Drawing on our qualitative analysis, we provide a discussion of the different components (i.e. frequency, intensity, time, type) of physical activity the accelerometer and Physical Activity Recall Assessment for People with SCI may be best suited to measure in the community-dwelling setting.

Qualitative analysis of individual data: interpretation considerations for the Physical Activity Recall Assessment for People with Spinal Cord Injury and accelerometers

Considerations for using the Physical Activity Recall Assessment for People with Spinal Cord Injury to derive moderate-vigorous physical activity

One important consideration when choosing to use the Physical Activity Recall Assessment for People with SCI is that it is subject to recall bias. Based on the data in Table 1, intermittent sport and leisure activities, activities of daily living, and short bouts of activity are three examples that may be particularly susceptible to recall bias. First, Physical Activity Recall Assessment for People with SCI-reported moderate-vigorous physical activity was consistently greater than accelerometer-reported moderate-vigorous physical activity when intermittent sport and leisure activities were performed. This may be a result of the difficulty recalling brief bouts of rest during intermittent sport and leisure activities. Often, participants reported sport or leisure activity practice for 1-3 hours and recalled being physically active during the entire practice period. It has been shown that participants sometimes include socializing, changing, and refreshment into the time reported doing physical activity (Shephard, 1967). This overestimation of actual time spent being physically active during intermittent sport and leisure activities may explain the greater values of moderate-vigorous physical activity obtained from the Physical Activity Recall Assessment for People with SCI vs. the accelerometer and highlights a strength of using accelerometers. The accelerometer's second-by-second collection of data allows for sensitivity to periods of rest when capturing intermittent sport and leisure activities.

Second, the Physical Activity Recall Assessment for People with SCI's suitability for measuring activities of daily living is unclear. A few examples from this study demonstrated how activities of daily living measured by the Physical Activity Recall Assessment for People with SCI are typically reported for longer durations and at higher intensities compared to the accelerometer measure. For instance, one participant reported 60 minutes of bowel care as moderate intensity physical activity. Another reported doing mechanical repairs for 3 hours as moderate intensity physical activity. Driving for extended periods was also reported as moderate intensity in one case. It is unlikely that these reports accurately reflected activity duration and intensity. This discrepancy may be a result of intensity of concentration or pain being interpreted as intensity of physical activity (Brodin, Swardh, Biguet, & Opava, 2017; Martin Ginis et al., 2005). This is another example where accelerometers may be beneficial for physical activity measurement by more accurately measuring actual bodily movement.

Third, brief activities such as wheeling in the house and short duration activities of daily living, may not have been accurately recalled. In most cases, individuals who reported no moderate-vigorous physical activity on the Physical Activity Recall Assessment for People with SCI showed several brief bouts (<1 minute) of moderate-vigorous physical activity using accelerometers. Failure to report brief bouts of activity has been cited as a limitation of the Physical Activity Recall Assessment for People with SCI and other self-report measures (Martin Ginis et al., 2005; Shephard, 2003). Taken together, the Physical Activity Recall Assessment for People with SCI is likely to over-estimate moderate-vigorous physical activity acquired during intermittent sport and leisure activities and activities of daily living, while moderate-vigorous physical activity from short bouts of activity appears to be under-estimated. Accelerometers may address limitations in recall and perceptions of intensity to provide more accurate collection of these types of activities.

Considerations for using accelerometers to derive moderate-vigorous physical activity

The primary consideration of using accelerometers is the difficulty in capturing accurate activity data during wheeling on an incline or uneven terrain, or when performing activities with external forces applied (e.g., lifting weighted objects). Little to no accelerometer-measured wheeled moderate-vigorous physical activity was detected when wheeling on an incline or uneven surfaces was reported on the Physical Activity Recall Assessment for People with SCI. For example, one participant followed a training regime of continuous wheeling on an incline for 30-60 minutes at a time as reported on the Physical Activity Recall Assessment for People with SCI and observed by a researcher. The accelerometer recorded <2 minutes of moderate-vigorous physical activity during these training sessions. It has been suggested that accelerometers may not accurately capture wheeled activity on a slope (Conger et al., 2015; Kooijmans et al., 2014). Likewise, participants who reported wheeling on sand, grass, or gravel had lower moderate-vigorous physical activity values on the accelerometer than the Physical Activity Recall Assessment for People with SCI. Wheeling on rough, uneven surfaces has been shown to require higher energy expenditures than wheeling on flat smooth surfaces (Collins et al., 2010). To this end, it is especially pertinent to consider that the determination of the accelerometer cut-point (or count) that determines the threshold for moderate-vigorous physical activity is derived from a test performed on a 1% grade, even surfaced treadmill. Thus, extrapolating these data from the carefully-controlled laboratory to daily life may result in a misrepresentation of moderate-vigorous physical activity.

Another example where external forces may affect the accuracy of the accelerometer is when participants' movements are externally loaded by weighted objects. Participants who identified doing resistance training or lifting activities typically reported higher values on the Physical Activity Recall Assessment for People with SCI than on the accelerometer. Under-reporting of resistance or lifting activities when using the accelerometer is consistent with a previous study showing that compared to indirect calorimetry, motion sensors worn by individuals with SCI underestimated energy expenditure for lifting objects (Bassett et al., 2000). Lifting heavier objects may result in slower movements and consequently a lower accelerometer-measured estimation of intensity, despite the increased force required to move the external weight. Thus, the sensitivity of the accelerometer when measuring either wheeling on inclined, uneven surfaces, or when lifting heavy objects is affected by its inability to detect the presence of external forces. Both inclined wheeling and resistance training/lifting may be instances where self-report measures such as the Physical Activity Recall Assessment for People with SCI may be better suited to account for the additional effort and energy expenditure required that is not captured by changes in speed of movement alone. Further, only the Physical Activity Recall Assessment for People with SCI provides information on the types of physical activity (e.g. resistance training, sports, etc.) that is being performed.

Study Limitations

This study included only manual wheelchair users; generalizability of these findings to those who use a power chair or are ambulatory is uncertain. The sub-analyses for accelerometers or the Physical Activity Recall Assessment for People with SCI to under- or over-report physical activity were made qualitatively and did not take into account exact time-alignment of activities or examine activities individually. Lastly, a criterion measure for assessing physical activity was not used in this study, without which we are unable to determine which method yielded the most valid estimate of physical activity. Future studies should examine the relationship between accelerometers and the Physical Activity Recall Assessment for People with SCI when measuring specific activity types (e.g. intermittent sport and leisure activities, inclined wheeling, strength activity) against a criterion measure (e.g. direct observation).

2.5 Summary

In summary, total and wheeled moderate-vigorous physical activity measured by an accelerometer and the Physical Activity Recall Assessment for People with SCI showed low agreement at the individual level, highlighting that there are differences in the specific physical activity patterns that each measure is able to capture. Future research should examine whether physical activity may be best measured using accelerometers and the Physical Activity Recall Assessment for People with SCI concurrently.

Chapter 3: Combining an integrated knowledge translation approach and behaviour change theory to develop a physiotherapist-delivered physical activity intervention for adults with spinal cord injury

3.1 Background

People with spinal cord injury (SCI) experience numerous barriers (e.g., lack of transportation, negative attitudes, increased cost to participate) to being physically active (Fekete & Rauch, 2012; Martin Ginis, Ma, Latimer-Cheung, & Rimmer, 2016). Considering these salient barriers, it is not surprising that 50% of people with SCI report participating in no leisure time physical activity (i.e., activity that requires physical exertion and that one chooses to do in their free time (Bouchard & Shephard, 1994; Martin Ginis et al., 2010). Indeed, people with SCI participate in less physical activity (PA) compared to their able-bodied counterparts as well as other populations with chronic physical conditions (Van den Berg-Emons, Bussmann, & Stam, 2010). Notably, large declines in PA occur following discharge from rehabilitation (van den Berg-Emons, Bussmann, & Haisma, 2008). Consequently, physiotherapists may be viable interventionists to support people with SCI to be physically active prior to discharge from hospital or community rehabilitation. In fact, evidence supports that physiotherapists are perceived as having the training, time, and confidence needed to provide information to help their clients become more physically active (Letts et al., 2011; Shirley, van der Ploeg, & Bauman, 2010; Whiteneck et al., 2011). However, knowledge and resources are two barriers that significantly impact physiotherapist-led PA promotion (Foulon, Lemay, Ainsworth, & Martin Ginis, 2012; Scelza, Kalpakjian, Zemper, & Tate, 2005). Thus, strategies and interventions are needed to address these barriers and meet the needs of physiotherapists to support their clients with SCI to be physically active.

It is recommended that the development and evaluation of complex interventions include the use of theory, take the local context into consideration, and be systematic (Craig et al., 2008). These three recommendations have been well-supported empirically: larger effects on PA behaviour have been observed following interventions that were developed using theory vs. those that were not (Ma & Martin Ginis, 2018; Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Webb, Joseph, Yardley, Michie, & Webb, 2010); consideration of the local context increases the relevance and maximizes the "potential fit" within the end-user's context (Curran et al., 2008); and, systematic intervention development using the best available evidence ensures the implementation of the highest quality interventions (Brouwers et al., 2010).

This paper describes the first use of both behaviour change theory and IKT to develop a physiotherapist-led behaviour change intervention to support clients with SCI to participate in PA. In order to address key recommendations for intervention development (Craig et al., 2008), we employed a) a health behaviour change theory to provide a blueprint of constructs to target individual behaviour change, b) an integrated knowledge translation framework to involve two end-user groups (people with SCI and physiotherapists) in developing the specific strategies used to target theoretical constructs, and c) a tool to systematically guide quality intervention development. Evidence-based and systematic translation of theories, frameworks and tools into an intervention added rigour of development and clarity of presentation and application (Brouwers et al., 2010).

3.2 Methods

Guiding frameworks

Three guiding frameworks were used to help inform the development of the intervention: the health action process approach (HAPA; Schwarzer, 2008; Schwarzer, Lippke, &

Luszczynska, 2011) model, the knowledge-to-action cycle (KTA; Graham et al., 2006), and The Appraisal of Guidelines, Research, and Evaluation II (AGREE-II; Brouwers et al., 2010). Each is briefly described next (See Figure 2 for how each framework contributed to the development process).

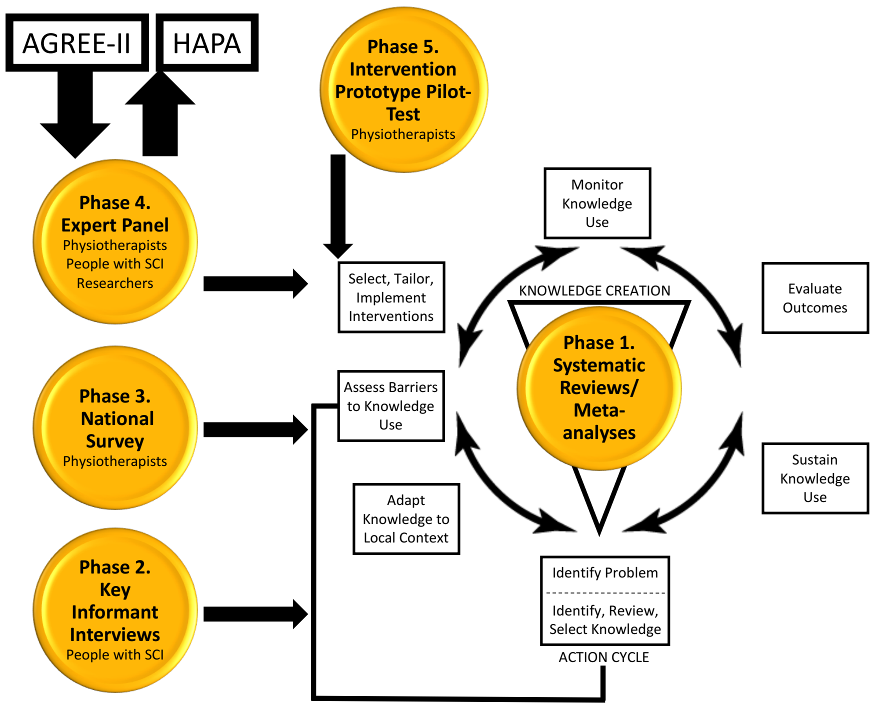

Figure 2. Study 2: Summary of the use of theories and frameworks to develop the intervention

Note. AGREE-II= Appraisal of the Guidelines, Research, and Evaluation, HAPA=Health Action Process Approach Model. Adapted from Graham et al., 2006.

HAPA model

The HAPA model (Schwarzer, 2008; Schwarzer et al., 2011) is a behaviour change theory that consists of both a continuum and stage layer. According to the HAPA, the continuum layer suggests individuals vary in their range of motivation to perform a health behaviour. The goal of an intervention is to move an individual to develop intentions, to translate those intentions into action, and ultimately to maintain the behaviour. The stage layer acknowledges that different psychosocial variables are salient depending on the individual's stage of motivation (i.e., pre-intender, intender, actor). Pre-intenders need to weigh the pros and cons of the behavioural outcomes (outcome expectancies), believe in their ability to perform the behaviour (task self-efficacy), and manage risk perceptions, in order to develop an intention to perform the behaviour. Moving from intention to action, and from action into maintenance, requires self-regulatory processes (Schwarzer, 2008). These include developing detailed plans (action planning), anticipating how to overcome barriers (coping planning), and monitoring the behaviour over time. Furthermore, belief in one's ability (i.e., self-efficacy) to develop plans and overcome barriers is important for initiating the behaviour while confidence in one's ability to recover from setbacks is imperative for maintenance. Interventions guided by the HAPA model have been implemented among people with SCI and yielded medium to large effects for changes in PA (Latimer, Martin Ginis, & Arbour, 2006; Martin Ginis et al., 2010).

The Knowledge-to-Action Cycle (KTA)

The KTA (Graham et al., 2006) is a framework used to translate research-based or experiential knowledge into implementation (e.g., in practice, policies, programs; Graham et al., 2006). It involves two phases: knowledge creation and the action cycle. The flow is fluid and permeable between these two phases, and there is potential for the knowledge creation phase to influence the action cycle at any point. Further, action phases may occur sequentially or all at once. During knowledge creation, knowledge moves down a 'funnel' of unrefined knowledge (knowledge inquiry), to the aggregation of knowledge (knowledge synthesis) to the development of clear, concise knowledge formats (knowledge tools or products).

The action cycle consists of 6 steps (see adapted framework in Figure 2) starting with identifying the problem or issue that needs addressing and critically appraising the relevant knowledge to determine its usefulness for the problem at hand. This knowledge is then tailored or customized to the setting and circumstances. Potential barriers to knowledge use are assessed, solutions are developed, followed by planning and execution (dissemination and implementation) of the intervention. After implementation, knowledge use should be monitored or measured and changes in outcomes evaluated. To maintain knowledge, a feedback loop through the action cycle should then be initiated. As noted in Figure 2, this paper reports our methods up to the point of implementation of the intervention.

AGREE-II

The 23-item AGREE-II was used as a framework to guide the development of stakeholder recommendations for the intervention. AGREE-II is the internationally-accepted, gold standard protocol for clinical guideline assessment, development, and reporting (Brouwers et al., 2010) and it has also been used to guide stakeholder involvement in the formulation of recommendations for PA promotion (Arbour-Nicitopoulos et al., 2013). AGREE-II is comprised of 23 items representing six quality domains (i.e., scope and purpose, stakeholder involvement, rigour of development, clarity of presentation, applicability, editorial independence). AGREE-II was used to ensure that the steps taken to formulate recommendations from the expert panel (Phase 4) were transparent, rigorous, systematic, and evidence-based. These steps are critical to successful intervention implementation (Brouwers et al., 2010). See Appendix B for how each of the 23-items were addressed during intervention development.

Intervention development process

People with SCI and physiotherapists (our two key end-user groups) were consulted to inform the research question and intervention content. Specifically, people with SCI who took part in our previous studies or who were members of adapted exercise facilities, and physiotherapists specializing in the care of people with SCI informed the methodology and interpretation of the findings. Guided by the HAPA model, the KTA, and AGREE-II, the intervention was developed in five phases.

Phase 1: Systematic reviews and meta-analysis

The first author was a collaborator on two recent systematic reviews (Martin Ginis et al., 2016; Tomasone et al., 2018) and a meta-analysis (Ma & Martin Ginis, 2018) which provided the evidence base for the intervention. A mix of SCI-specific and general physical disability evidence was used because of the limited availability of high-quality SCI-specific information. This evidence base included:

1) The factors that affect PA participation among people with physical disability (Martin Ginis et al., 2016).
2) The interventions and associated behaviour change techniques used to increase PA behaviour and its antecedents among people with SCI (Tomasone et al., 2018).
3) The interventions, behaviour change techniques, and modes of delivery used in randomized controlled trials of PA interventions for people with physical disability (Ma & Martin Ginis, 2018).

Phase 2: Key informant interviews with people with SCI

Interviews were conducted with 26 adults with SCI who had recently participated in a larger study (McCracken et al., 2018). Participants had injury levels ranging from C5-L2, were 31-64 years old, and 1.2-43.0 years post-injury. Open-ended questions (Appendix C) were administered to understand participants' past experiences of effective and ineffective physiotherapist-led PA promotion efforts and to obtain their recommendations for improvement (Appendix D).

Phase 3: National survey of physiotherapists

A national survey was employed to assess: a) whether physiotherapists wanted an intervention to promote PA; b) physiotherapists' intervention needs and barriers to promoting PA; and c) their intervention delivery preferences (Appendix E). Survey questions were adapted from previous physiotherapist PA promotion surveys from other countries (Donoghue, Doody, & Cusack, 2011; Shirley et al., 2010) and were pilot-tested by three physiotherapists. Invitations to participate in the survey were sent out via email by the Canadian Physiotherapy Association to practicing (>1yr) physiotherapists across Canada. Survey results were summarized using frequency statistics (Appendix F).

Phase 4: Expert panel meeting

End-users were engaged in developing an intervention prototype. A panel of experts was formed consisting of people with SCI (paraplegia and tetraplegia, n=5), inpatient, outpatient, and private practice physiotherapists (n=5), a physiatrist, and behaviour change researchers (n=2). A meeting was scheduled to discuss and identify the most relevant results from Phases 1-3, highlight missing information, and develop strategies for disseminating the intervention. Prior to the meeting, members were provided with a summary of the results of Phases 1-3. An adapted version of the AGREE-II (Appendix B) was followed to guide the meeting agenda. A checklist of panel recommendations was generated from the meeting and a coder external to the project checked the intervention prototype to confirm the recommendations were applied. Revisions of the intervention prototype were sent to expert panel members until all members were satisfied with the content.

Phase 5: Intervention prototype pilot test

Participants

Twenty physiotherapists (16 female) who had been practicing for an average of 16.6 years participated in this project, 15 of whom had previously worked with clients with SCI.

Design

Using a two-group, pre-test post-test design, physiotherapist-perceived feasibility and efficacy of the intervention were pilot-tested to refine the development of the intervention content and to inform its delivery. Physiotherapists were matched by level of experience (years and number of clients serviced/year) in working with people with SCI and randomized to an experimental or a control group.

Measures

A modified theoretical domains framework (TDF) measure (Huijg, Gebhardt, Crone, Dusseldorp, & Presseau, 2014) was used to evaluate participants' perceptions of the extent to which the intervention addressed barriers to PA promotion (i.e., barriers identified in Phase 3; Appendix G). Perceived knowledge (4 items), skills (2 items), beliefs about capabilities (4 items), and innovation/environmental context and resources (2 items) were assessed and item scores were averaged for each domain. A modified APEASE criteria measure was implemented to assess affordability (1 item), practicality (4 items), effectiveness (1 item), acceptability (1 item), safety (1 item) and equity (1 item) of the intervention (Michie, Atkins, & West, 2014; Appendix H). Participants responded to each item on a 7-point Likert scale (1=strongly disagree, 7=strongly agree). Lastly, a test was administered comprised of 20 true or false questions to assess knowledge of SCI-specific PA information.

Procedure

All measures were completed online using Fluid Surveys [Survey Monkey, Ottawa, ON]. At baseline, physiotherapists randomized to the experimental group completed the TDF measure. Immediately following, the first author (JM) sent them an electronic copy of the intervention and explained it through a one-on-one, single-hour lecture and case study via video conferencing technology. Participants had the opportunity to ask questions before completing the APEASE measure. Experimental condition physiotherapists were re-contacted one week later for post-testing which consisted of the knowledge test, re-administration of the TDF measure, and a semi-structured interview to provide feedback on the intervention content. Participants in the control group completed the knowledge test and TDF measure at baseline. They returned one-week later to complete the TDF measure, were then delivered the intervention resource in the same manner as the intervention group, and completed the APEASE and a semi-structured interview.

Statistical Analyses

Cronbach's alphas for the TDF domain items were >0.90. ANCOVAs with baseline scores as the covariate were conducted to compare TDF scores between groups. Independent samples t-tests were conducted to compare knowledge scores between groups and descriptive statistics were calculated to summarize APEASE scores.

3.3 Results

The following is a summary of the key findings from each phase of the intervention development process. Key findings were used to inform the content, format, and delivery of the intervention.

Phase 1: Systematic reviews and meta-analysis

The systematic review of reviews demonstrated that there are over 200 barriers to participating in PA and that transportation and finances are particularly salient barriers in the SCI population (Martin Ginis et al., 2016). A key recommendation from this review was a call for multi-sectoral (e.g., researchers, healthcare providers [e.g., physiotherapists], recreation providers) and multi-level (i.e., individual, inter-individual, community, institutional, and policy) PA interventions (Martin Ginis et al., 2016).

The systematic review and meta-analysis of PA interventions highlighted the most effective behaviour change techniques for changing PA behaviour and its antecedents in people with SCI and other physical disabilities. These techniques included self-monitoring, feedback on behaviour, goal setting, action planning, problem-solving, reviewing behavioural goals, and information about health consequences (Ma & Martin Ginis, 2018; Tomasone et al., 2018).

Phase 2: Key informant interviews with people with SCI

Participants reported few instances where they felt that their physiotherapist was not helpful for promoting PA. In three cases, participants indicated the treatment they received inhibited function, thereby preventing them from engaging in PA. Positive examples of PA promotion included the physiotherapist providing encouragement or motivation, introducing them to athletes with SCI, and encouraging or training them to compete in sport. Key recommendations included providing referrals to adapted programs or facilities, connecting with peers, tailoring or asking clients what they want, educating on financial support, and providing exercise prescriptions. All participant response themes are included in Appendix D.

Phase 3: National survey of physiotherapists

Respondents included 204 physiotherapists who served a general patient population and 35 who had direct experience working with patients with SCI (total n=239). Respondents with experience treating clients with SCI were primarily female (80%), had been practicing for 1-5 years (40%), and mostly practiced in neurology (49%). Importantly, ninety percent of respondents indicated that they would use a resource outlining how to promote PA to their clients. Key barriers to PA promotion included lack of knowledge, confidence, and resources (e.g., time, tools, programs). These barriers informed the theoretical domains (knowledge, skills, confidence, and environmental resources) that were assessed in the intervention prototype pilot-test (Phase 5).

Regarding intervention development, physiotherapists preferred to receive the intervention resource from a physiotherapist; however, researchers and representatives with SCI also seemed to be acceptable. The delivery format of the intervention resource was preferred to be online or an in-person workshop outside of their clinic. The most desired content included behaviour change techniques, example exercises, and a list of benefits and barriers to PA. The most feasible options for delivery of the intervention to clients were either brief, one-on-one counselling integrated into regular consultations or resource distribution. A summary of all survey questions and response frequencies is included in Appendix F.

Phase 4: Expert panel

A list of recommendations for the intervention format, content, and delivery was made following the panel meeting and confirmed by the panel members (Appendix I). All but two recommendations were incorporated into the intervention. First, the suggestion for an online searchable database listing all accessible facilities by geographical location was omitted, due to the absence of resources to develop and maintain such a database. Second, 'framing that PA for people with SCI is similar to PA in the general population' was not included in the intervention as we wanted to highlight SCI-specific safety considerations (e.g., temperature regulation, autonomic dysreflexia). An important outcome of the expert panel meeting was the selection of the HAPA model as the guiding framework for tailoring strategy selection when implementing the intervention among people with SCI. Panel members described the need to select strategies based on participants' level of motivation and emphasized the importance of using behavioural strategies (e.g., self-regulation) to translate intention to action. The behavioural researchers discussed these points and decided the HAPA model was a good fit to guide the intervention based on the panel's recommendations and previous literature (Arbour-Nicitopoulos, Martin Ginis, & Latimer, 2009; Latimer, Martin Ginis, & Arbour, 2006). A prototype of the intervention was sent to panel members for feedback. Two iterations of the intervention were made until all panel members approved of the content and format. A reviewer external to the project reviewed the development and prototype of the intervention to ensure all recommendations were addressed (except for the two recommendations described above) and a separate reviewer confirmed that AGREE-II checklist items were met. The authors received confirmation that all AGREE-II checklist items had been fulfilled (for a detailed summary of how the expert panel and resulting recommendations fulfilled all 23 items of the AGREE-II checklist see Appendix B).

Phase 5: Intervention prototype pilot test

Results of the t-tests on the TDF constructs demonstrated that scores for perceived knowledge, skills, confidence, and environmental resources were significantly greater in the experimental group compared to the control group (all *p*s<0.04; see Table 2). Independent samples t-tests showed significantly higher scores on the test of SCI-specific PA knowledge for the experimental group (M=16.1±2.1) compared to the control group (M=11.3±1.6), t=5.8, p<0.001.

Table 2. Study 2: Baseline-adjusted post-test scores for the Theoretical Domains Framework (TDF) subscales

TDF Domain	Experimental	Control	F Group	*p*	Cohen's d
Confidence	6.1±0.3	5.1±0.3	5.0	0.04	1.1
Knowledge	6.2±0.3	4.8±0.3	15.5	0.001	1.6
Skills	6.1±0.2	5.0±0.2	12.1	0.003	1.8
Environmental Resources	6.0±0.3	4.8±0.3	9.4	0.007	1.3

Note. TDF=theoretical domains framework. Scores are post-test estimated marginal means±SE. Values are adjusted for the baseline scores for each subscale. TDF item scores are out of 7

One participant was missing APEASE data due to malfunction of the survey software. Therefore, 19 respondents were included in the descriptive statistics summarized in Figure 4. Almost all physiotherapists either strongly agreed or agreed that the intervention was affordable, practicable, effective, acceptable, had no side-effects/safety concerns, and was equally beneficial for physiotherapists across different settings. All physiotherapists either strongly agreed or agreed they would recommend the intervention to their colleagues. Changes to the intervention resource were made following recommendations from the semi-structured interviews. This included the addition of a section on wheelchair seating, recommendations for adapted programs, facilities, and resources, and a summary ‘cheat sheet’.

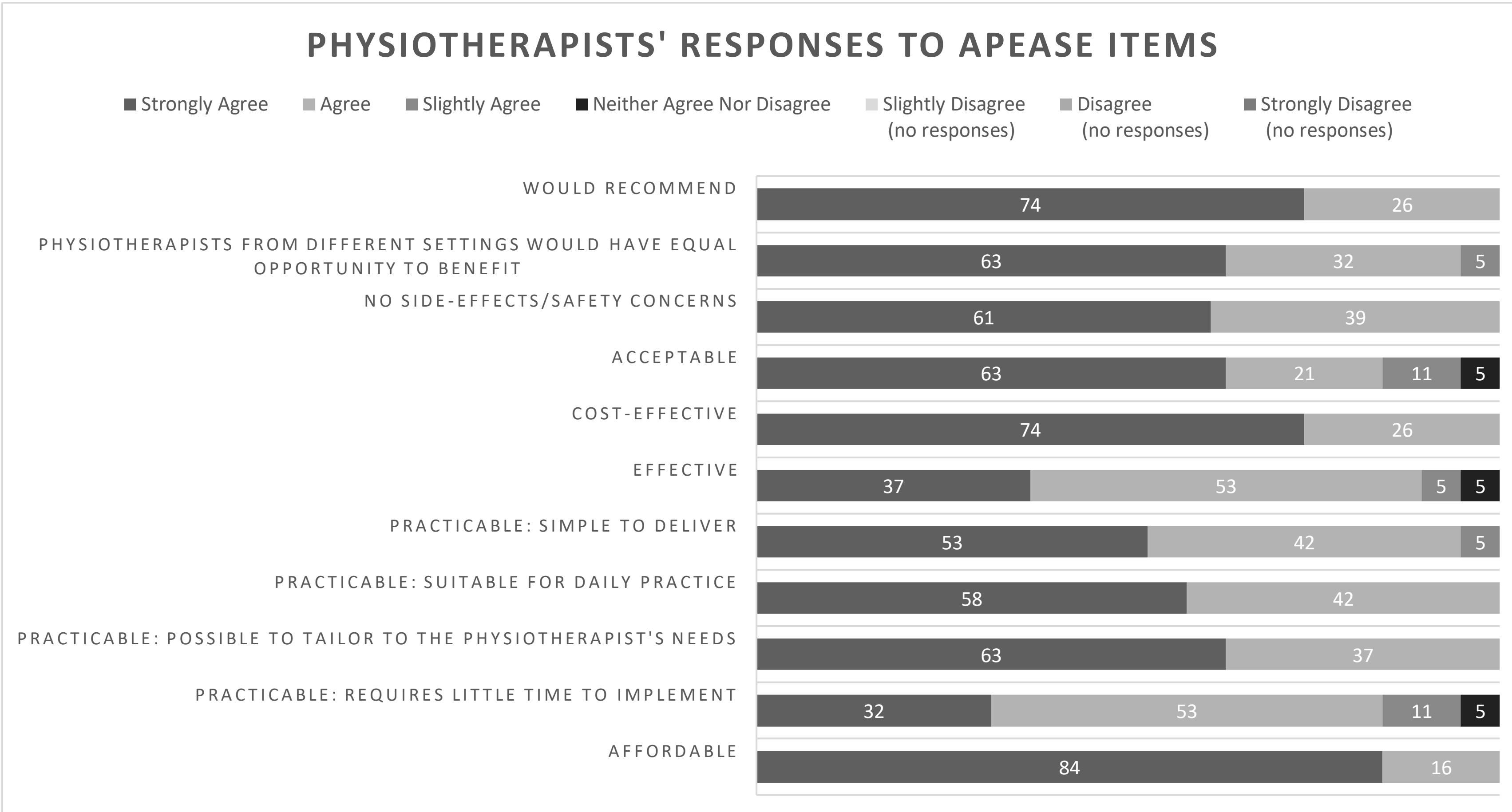

Figure 3. Study 2: Physiotherapist (n=19) response frequencies (%) to APEASE questionnaire items

Summary of the intervention

This intervention is the product of a 5-phase development process. Briefly, the intervention guides physiotherapists to tailor PA-enhancing strategies based on the client's stage of motivation (pre-intender, intender, actor) and their context (e.g., resources, barriers, preferences). Three overarching intervention strategies are used:

1) Education: includes safety information, basics of PA, the SCI PA guidelines (Martin Ginis et al., 2011), and behaviour change techniques (e.g., action planning, monitoring, using prompts/cues).
2) Link & refer: provides resources or referrals to address key barriers such as finances and transportation, local resources and facilities, information on developing peer connections, and suggests consideration of other supports such as family, occupational therapists, and SCI-specific physiotherapists.
3) Tailored prescription: specifies instructions for tailoring strategies to the client, examples of different activities organized by level of commitment and competition, basic exercise prescription, sample exercise programs, and ways to adapt common exercise equipment.

3.4 Discussion

This project is the first to combine an IKT process with a behaviour change framework and a tool to systematically guide the formulation of stakeholder recommendations to develop an intervention to assist physiotherapists in promoting PA to their clients with SCI. Over 300 end-users were engaged throughout the 5-phase process to inform the development and implementation of the intervention. Preliminary testing of the intervention demonstrated that it was effective in addressing physiotherapist-identified barriers to promoting PA, was feasible for implementing in practice, and increased SCI-specific PA knowledge.

Novelty of the methods

The 5-phase process used in this project contributes uniquely to literature on IKT intervention development methods in two ways. First, it serves as a model for how to involve two end-user groups using the KTA. Engaging two end-user groups required consideration of both the barriers and facilitators for physiotherapists to deliver the intervention and for people with SCI to perform the behaviour. In other words, end-user opinions informed both how the intervention guides implementation by physiotherapists and how the intervention changes behaviour of people with SCI. Other studies have used the KTA to develop interventions; however, consideration of the healthcare provider's (interventionist's) context is often overlooked (Connell, Mcmahon, Redfern, Watkins, & Eng, 2015). Involvement of end-users has been shown to be the best predictor of the translation of research into practice (Curran et al., 2008). For effective translation, both the interventionist and recipient of the intervention should be equally considered. Our intervention development process provides a model for doing so.

Second, the 5-phase process was rooted in theory and validated frameworks. The Medical Research Council calls for interventions to be developed using theory, to consider the local context, and for the development process to be systematic (Craig et al., 2008). This development process used behaviour change theory (HAPA) to guide intervention strategy selection, a knowledge translation framework (KTA) to engage end-users in the development process, and a tool to help ensure the evidence-based and systematic development of a quality intervention (AGREE-II). Previous interventions have used the HAPA model (e.g. (Arbour-Nicitopoulos et al., 2009; Latimer et al., 2006)), the KTA (e.g. (Sinden & MacDermid, 2014)), and the AGREE-II (e.g. Arbour-Nicitopoulos et al., 2013) to guide resource or intervention development independently. Using all three meant that the advantages of using theory, co-creation of knowledge, and rigorous systematic development were combined. The intervention's preliminary evidence for usability in the physiotherapist context supports the utility of this development approach.

Results from the pilot test of the intervention demonstrated that improvements occurred in all theoretical domains. These included perceived and tested knowledge, confidence, skills, and resources to deliver an SCI-specific PA intervention. However, it is important to distinguish between perceived knowledge to promote PA and actual knowledge. In the national survey of physiotherapists (Phase 2), physiotherapists *believed* they had the knowledge to promote PA but less than half the respondents could correctly identify the national guidelines for PA (Canadian Society for Exercise Physiologists, 2011; Martin Ginis et al., 2011). In the pilot test, following exposure to the intervention, physiotherapists demonstrated *both* perceived and actual knowledge for promoting PA. Confidence has been shown to be the strongest predictor of whether a physiotherapist prescribes PA (Rea, Marshak, Neish, & Davis, 2004). Experimental group physiotherapists reported large-sized increases in confidence to promote PA compared to the control group, suggesting an increased likelihood that physiotherapists would promote PA in practice. The intervention also addressed skills and resources, which were two other important barriers to PA promotion identified by the physiotherapists in the national survey. Addressing barriers, combined with demonstrated improved knowledge and confidence to promote PA supports the potential for uptake and implementation once the intervention is disseminated more widely (Curran et al., 2008; Rea et al., 2004).

Dissemination and anticipated implications for end-users

Dissemination plans are unique for the two end-user groups. For physiotherapists, the intervention content will be delivered through presentations and in-clinic training. For physiotherapists who want to use the intervention as a quick reference guide, the intervention will also be available online. Using the intervention to guide physiotherapist training will provide physiotherapists with the potential to demonstrate PA knowledge for their clients with SCI. For people with SCI, those who do not receive the intervention from their physiotherapist can bring a printed version of the intervention to their physiotherapists or refer them to the online copy of the intervention. This may empower the client to influence his or her own treatment plan by increasing education and information about self-management of one's condition (Taylor et al., 2014). Together, clients and physiotherapists can work to prepare for the start, or continuation, of a physically active lifestyle during the transition to the community. Developing the skills to self-manage their own health and collaborating with health professionals are important prerequisites for a successful clinic to community or "*patient-to-participant"* transformation (Sinden and MacDermid, 2014; pg 4).

Limitations

Some limitations to the development process should be acknowledged. First, the national survey of physiotherapists did not include respondents from all provinces (e.g., Newfoundland, Saskatchewan, Manitoba). Resources (e.g., facilities, organizations) specific to each province were highlighted in the intervention; however, feedback regarding the usability of these resources specific to each province has not been sought. Likewise, intervention development focused on the Canadian context, thus it is unknown whether the intervention is applicable in other countries. Second, the generalizability of the intervention to other healthcare providers is currently unknown. Our end-users suggested occupational therapists, recreational therapists, and personal trainers may be other interventionists that could deliver the intervention. A larger scale randomized controlled trial employing physiotherapists as interventionists should be implemented to generate more conclusive findings about the effectiveness of the intervention. Third, there was no comparison intervention that used alternative methods to understand whether this 5-phase process was more effective than other intervention development methods. To date, there has been no established consensus on the optimal method for intervention development; however, exploration of new methods has been encouraged (Curran et al., 2008). This research provides one novel example of how IKT, behaviour change theory, and a tool for developing evidence-based, high quality recommendations can be used for intervention development.

3.5 Summary

This is the first PA intervention among people with SCI to be developed using behaviour change theory, an IKT approach, and a systematic development tool. Importantly, the 5-phase process facilitated the involvement of over 300 end-users which is anticipated to increase the adoption and effectiveness of the intervention when it is implemented in the community. Future research will examine the efficacy of the intervention to change PA behaviour among people with SCI. Given the numerous barriers people with physical disability report, intervention developers are encouraged to involve end-users and tailor intervention content and delivery accordingly.

Chapter 4: Use of education, referral, and prescription to increase physical activity, psychosocial predictors, and fitness in individuals with spinal cord injury: A randomized controlled trial

4.1 Background

Physical activity (PA) participation in people with spinal cord injury (SCI) is alarmingly low even when compared to the poor participation rates in the able-bodied population (Van den Berg-Emons, Bussmann, & Stam, 2010). In fact, people with SCI show the lowest PA levels of populations with chronic disability (e.g. stroke, cerebral palsy, osteoarthritis) (Van den Berg-Emons et al., 2010). Improving these low levels of PA participation could have both health and economic impacts for people with SCI. For instance, participating in PA as little as 2-3 times per week has been shown to improve aerobic fitness, which is significantly correlated with functional ability (Hicks et al., 2011; Noreau, Shephard, Simard, Pare, & Pomerleau, 1993; van der Scheer et al., 2017). It has also been shown that the risk of hospitalization in the first year after injury is cut in half for patients with SCI who exercise at least two times per week (Dejong et al., 2013). With decreased hospitalization and improved functional independence from chronic exercise (Duran, Lugo, Ramı, & Eusse, 2001; Lugo, Salinas, & García, 2009), savings to the healthcare system of US$290,000 to US$435,000 have been projected over an individual's lifetime (Miller & Herbert, 2016). However, improving PA participation in people with SCI does not come without challenges. Transportation, negative attitudes, access to appropriate facilities and equipment, and lack of accessible programming are just some of the barriers (Fekete & Rauch, 2012; Martin Ginis, Ma, Latimer-Cheung, & Rimmer, 2016). Indeed, over 200 barriers have been reported to affect PA participation among individuals with physical disability (Martin Ginis et al., 2016). Interventions that can effectively address these barriers are sorely needed.

Theory-based behavioural interventions are a particularly promising approach to increasing the likelihood of PA behaviour change. Systematic reviews have shown that PA interventions that are theory-based tend to be more effective than those that are not (Ma & Martin Ginis, 2018; Taylor, Conner, & Lawton, 2012; Webb, Joseph, Yardley, & Michie, 2010). In studies of people with SCI, social cognitive theories have shown utility for the design of PA-enhancing interventions (Tomasone et al., 2018). Across samples of people with physical disability, theory-based interventions have shown medium-sized effects (Hedge's g=0.52 95% CI [0.38 to 0.68]) (Ma & Martin Ginis, 2018). The Health Action Process Approach (HAPA) (Schwarzer et al., 2011) is one social cognitive model that has been used to develop effective PA behaviour interventions in people with SCI (Latimer, Martin Ginis, & Arbour, 2006; Martin Ginis et al., 2010).

The HAPA model proposes that to change behaviour, different constructs should be targeted for intervention depending on the individual's stage of motivation for a behaviour (i.e., pre-intender, intender, or actor stage) (Schwarzer et al., 2011). Specifically, for those who have not developed intentions to do PA (pre-intender), outcome expectancies, risk perceptions, and task self-efficacy need to be addressed. For those who want to do PA but haven't been able to consistently bridge the intention-behaviour gap (intender), self-regulatory strategies (e.g., action planning, coping planning), task self-efficacy, and maintenance self-efficacy should be targeted. Lastly, for those looking to continue being physically active (actor), maintenance and recovery self-efficacy and action control (e.g., monitoring, feedback) should be the focus of intervention. Barriers and resources (e.g., knowledge, social support) can influence participation at all stages and should be targeted regardless of stage.

Martin Ginis et al. (2013) demonstrated that measures of HAPA constructs were stronger in actors vs. intenders, and in intenders vs. pre-intenders. Further, targeting the specific HAPA constructs of action planning and coping planning, which are proposed to translate intentions into actions (Schwarzer et al., 2011), has been shown to significantly increase PA behaviour in people with SCI (Arbour-Nicitopoulos, Ginis, et al., 2009; Latimer et al., 2006). While these interventions demonstrate the efficacy of an intervention that targets *two* HAPA constructs, there has yet to be an RCT evaluating the effects of an intervention that targets *all* the HAPA constructs among people with SCI.

Furthermore, no published RCT has used an integrated knowledge translation (IKT) process to develop a PA intervention for people with SCI. The IKT approach involves end-users throughout the research process (for an example model of IKT see Graham et al., 2006). IKT allows the researchers to understand the problem, context, and barriers from the end-user's perspective, ultimately ensuring the research is relevant and impactful for end-users (Graham et al., 2006). Given the unique needs of people with SCI (Fekete & Rauch, 2012), using an IKT approach seems appropriate when developing PA interventions for this population. Moreover, the use of behaviour change theory complements the use of IKT. Theories identify *which* constructs to target, while the IKT process can determine *how* a construct is targeted when researchers work with end-users to inform the appropriate strategies, modes of delivery, settings, and interventionists to be used. Accordingly, this paper reports on an RCT that tested a HAPA-based PA intervention for people with SCI, developed through an IKT process involving over 300 physiotherapists and clients with SCI (Ma, Cheifetz, Todd, Chebaro, Phang, Shaw, Whaley, & Martin Ginis, 2018). It was hypothesized that the intervention would result in significant improvements in PA behaviour, fitness, and HAPA model construct measures relative to a control condition.

4.2 Methods

Participants

Based on a previous intervention employing goal setting and tailored exercise programs for individuals with SCI, a large-sized effect (*d* =.96) on PA was expected (Latimer-Cheung et al., 2013). A total sample size of 30 was needed to have 80% power to detect a large-sized effect at $p<0.05$ (Faul et al., 2007).

Participants were recruited from the greater Vancouver, Canada area from May to July 2017 through poster and website advertisements, community events, and by contacting participants from past studies who had previously provided consent to be contacted for future studies. Inclusion criteria were: a) 18-65 years old; b) chronic (>1year) SCI; c) physician clearance to exercise; and d) currently performing <150 min of moderate to vigorous physical activity (MVPA)/week (the Canadian PA guidelines; Canadian Society for Exercise Physiologists & Participaction, 2010). Exclusion criteria were: a) trauma or surgery within the past 3 months; b) history and/or symptoms of cardiovascular or cardiopulmonary disease or problems; c) an active stage 3 or 4 pressure ulcer; d) lack of proficiency in the English language that would prevent ability to follow instructions; and e) any unstable medical/psychiatric condition that would likely affect the ability to complete the study.

Randomization and design

An 8-week randomized controlled trial (RCT) design was used. Eight weeks has been shown to be an adequate duration to improve both PA and fitness improvement among people with SCI (Hicks et al., 2011; Latimer et al., 2006). Participants were matched for baseline leisure time PA levels and a random numbers generator was used to assign each member of the matched pair to the intervention or control condition (i.e., 1=intervention, 0=control). An a priori plan was formulated to replace dropouts who did not complete the second PA measurement (week four); drawing from a list of volunteers who had not yet been contacted for the study, matched pairs were created and, using a random numbers generator, one individual from each pair was assigned to the dropout's condition.

Individuals were informed verbally of their group assignment after baseline measures were completed. Neither assessors nor participants were blinded to condition assignment; however, data analysis was performed blinded. This trial has followed the pre-registered protocol listed at clinicaltrials.gov (Identifier: NCT03111030).

Measures

Demographics. Participant demographics were collected using an online form and included age, gender, level of injury (paraplegia or tetraplegia), completeness of injury ("complete" defined as "no motor or sensory function below level of injury"; Maynard et al., 1997), years post injury, primary mode of mobility, ethnicity, highest level of education completed, medications, and any current medical complications.

Accelerometer-measured physical activity. Participants were instructed to wear a wrist accelerometer (GT9X, ActiGraph LLC, FL) on their non-dominant hand during all waking hours, except when bathing/swimming, for six consecutive days. To be included in the analysis, at least 10 hours of accelerometer wear per day was required (Troiano et al., 2007). The validity of accelerometers to measure PA in individuals with SCI has been supported (Conger et al., 2015; Warms & Belza, 2004). However, it has been suggested that individually calibrated cut-points be used to analyze MVPA (McCracken et al., 2018). This recommendation has only been tested in manual wheelchair users. Because our study included people using all types of mobility aids, total vector magnitude counts were used instead of MVPA cut-points. Accelerometers do not capture all PA types in people with SCI; it has been recommended accelerometry be used alongside a self-report measure of PA (Ma, McCracken, Voss, Chan, et al., 2018).

Leisure Time Physical Activity Questionnaire for People with SCI (LTPAQ-SCI). Participants completed the LTPAQ-SCI which is a self-report measure that assesses minutes of mild, moderate, and vigorous intensity leisure time PA (i.e., activity that requires physical exertion and that one chooses to do in their free time; Bouchard & Shephard, 1994) performed over the past seven days (Appendix J). Before administering the questionnaire, the first author (JM) also reviewed validated SCI-specific definitions of intensity with the participant (Martin Ginis, Latimer, Hicks, & Craven, 2005). Support for the LTPAQ's criterion validity and test-retest reliability has been previously demonstrated in a sample of 103 men and women with SCI (Martin Ginis, Phang, Latimer, & Arbour-nicitopoulos, 2012).

Aerobic fitness: Peak oxygen uptake test (VO2peak). Participants performed a graded exercise test on an electronically braked arm ergometer (Angio Rehab arm ergometer, Lode, Groningen, the Netherlands). Participants wore a fitted mask and expired gases were collected in a mixing chamber using a metabolic gas analyzer (Quark CPET, Cosmed, Rome, Italy). The incremental exercise test required participants to maintain a cycling rate of 50 revolutions per minute (rpm) for the duration of the test. After an initial warm-up at 0W, power output was increased each minute at a rate of 5W/min for participants with tetraplegia, or 10W/min for participants with paraplegia, until volitional exhaustion (i.e., dropping below 30 rpm) (Claydon, Hol, Eng, & Krassioukov, 2006). Ratings of perceived exertion (Borg 6-20 scale) (Borg, 1970) were collected in the final 10-seconds of each stage. VO2 peak and peak power output were calculated using 30 second rolling averages.

Health Action Process Approach model constructs: Measures of the HAPA constructs were drawn from previous SCI studies where possible (Arbour-Nicitopoulos et al., 2009; Latimer-Cheung et al., 2013; Martin Ginis et al., 2013). HAPA group classification (i.e., pre-intender, intender, actor) was determined using a single item that assessed intentions for or current participation in regular LTPA (Marcus & Simkin, 1993). Motivational constructs were measured including outcome expectancies (6 items) (Martin Ginis et al., 2013), task self-efficacy (aerobic and strength; 10 items) (Bandura, 1997), and intentions (2 items) (Arbour-Nicitopoulos, Ginis, et al., 2009). Two items for risk perceptions were developed to measure whether autonomic dysreflexia and injury from exercise were perceived risks (2 items). Volitional phase constructs included planning (2 items) (Scholz, Sniehotta, & Schwarzer, 2005), coping (7 items) (Sniehotta, Scholz, Lippke, Ziegelmann, & Luszczynska, 2002), scheduling (4 items) (Arbour-Nicitopoulos, Martin Ginis, et al., 2009), and barrier self-efficacy (6 items) (Sniehotta et al., 2002), as well as the self-regulatory constructs of action planning (4 items) (Sniehotta, Scholz, & Schwarzer, 2005) and monitoring (6 items) (Sniehotta, Scholz, & Schwarzer, 2005).

In addition, knowledge was measured using six questions evaluating participants' knowledge to perform the SCI PA guidelines for improving fitness (Martin Ginis et al., 2011) (e.g., "I know how to do 3 sets of 8-10 repetitions of strength exercise for each major functioning muscle group", "I know how to do at least 20 minutes of moderate to vigorous intensity aerobic exercise"). *Barriers* were evaluated using six items that reflect the most commonly reported barriers to PA participation (Cowan, Nash, & Anderson, 2013; Martin Ginis et al., 2016; e.g., "equipment is available to help do PA"). *Social support* was evaluated using a modified version of Sallis' social support questionnaire (Sallis, Grossman, Pinski, Patterson, & Nader, 1987). This version included three questions to evaluate emotional social support (e.g., "over the past 9 weeks, my friends and family gave me encouragement to stick with my PA program") and five questions to measure practical social support (e.g., "over the past 9 weeks, my friends and family provided transportation to get to PA"). See Appendix K for complete survey.

All items were assessed on a 7-point Likert scale ranging from 1='strongly disagree' to 7='strongly agree'. Survey items for each construct had Cronbach's alpha values >0.7 at pre- and post-intervention indicating acceptable internal consistency. Item scores for each construct were averaged to provide an aggregate score which was used in the analyses.

Procedure

All testing was performed in a research facility setting. Day 1 testing included the collection of demographic information, and the VO_{2peak} test. Participants were then given an accelerometer to wear and they returned seven days later to complete HAPA measures and the LTPAQ. Participants randomized to the intervention condition completed their first PA coaching session and participated in eight, weekly coaching sessions. Participants randomized to the waitlist control condition were scheduled to begin their weekly coaching sessions after completion of post-intervention measures nine weeks later. All measures were repeated at post-intervention. In the intervention condition, self-reported and accelerometer-measured PA was assessed at baseline, week 4, week 7, and post-intervention (9 weeks) to examine at which time points intervention effects occurred. Self-reported PA was measured at 1, 2, 3, and 6-months follow-up to examine whether intervention effects were maintained. Control group PA was only measured at baseline and post-intervention.

Intervention

Development process: The intervention is unique for its development process (Ma et al., under review) which is rooted in both behaviour change theory (HAPA) and a formal IKT process guided by the Knowledge to Action Cycle (Graham et al., 2006). Specifically, the HAPA model provided the framework for identifying the constructs to be targeted for each participant based on his or her status as a PA pre-intender, intender, or actor, while knowledge gained from the IKT process informed *how* those constructs were targeted (i.e., which behaviour change techniques were used to target the constructs).

A five-stage IKT intervention development process took place over two years and involved over 300 end-users (Ma et al., under review). Briefly, evidence was extracted from three systematic reviews on the unique barriers to PA that must be addressed (Martin Ginis et al., 2016) and the behaviour change techniques (BCTs; observable, reproducible, and irreducible components responsible for eliciting changes in behaviour within an intervention; Michie et al., 2013) found to be most effective for changing PA behaviour in people with SCI and other physical disabilities (Ma & Martin Ginis, 2018; Tomasone et al., 2018). End-users (physiotherapists and people with SCI) were involved in the development and evaluation process through a national online survey, key informant interviews, an expert panel consensus meeting, a pilot-test of physiotherapists who did or did not receive the intervention content to evaluate changes in knowledge and projected feasibility of implementing the intervention in practice, and informal consultations provided throughout the process. Upon completion of these steps, the present RCT was designed to test the efficacy of the intervention (Ma et al., under review).

General overview of intervention implementation: The intervention consisted of a one-hour introductory session followed by eight, weekly 10-15 minute behavioural PA coaching sessions for a total time commitment of 140-180 minutes over eight weeks (average session time=12.5 minutes). The intervention was delivered by the first author who is a personal trainer with seven years of experience training clients with SCI. A researcher interventionist was deliberately chosen to maximize intervention implementation and fidelity for purposes of testing intervention efficacy. Coaching sessions were delivered either face-to-face at the research facility, over Skype, or when the former modes were not possible, over the phone. Participants chose where their PA was performed (e.g. home, gym, community centre, etc.). Tailoring and the individual's HAPA stage was used throughout the intervention to match BCT strategies to participant needs and preferences. The only materials distributed in the study were an exercise band which was given to both the intervention and control group participants, and a tailored exercise program given to the intervention group participants. An overview of the structure and BCTs used in the intervention are outlined in Table 3.

Table 3. Study 3: Structure and behaviour change techniques included in the intervention

Details	Behaviour change technique (Michie et al., 2013; if applicable)
Introductory Session	
Current PA levels were reviewed	
Participants were asked what PA duration and frequency goals they would like to set, along with how they would like to accomplish these goals (i.e., the types of PA they would prefer to do). At a minimum, the interventionist suggested achieving the international SCI exercise guidelines to improve fitness (at least 20 minutes of moderate-vigorous aerobic activity twice/week and strength training twice/week) (Martin Ginis et al., 2011). For those already exceeding the fitness guidelines, the international SCI exercise guidelines to improve cardio-metabolic health was set as the goal (at least 30 minutes of moderate to vigorous aerobic activity three times/week (Martin Ginis et al., 2017) plus strength training twice/week.	1.1 Goal setting 1.4 Action planning
Potential barriers to accomplishing these goals were identified and solutions were discussed	1.2 Problem solving
An understanding of the resources, equipment, and facilities participants currently had available to them were discussed.	

Details	Behaviour change technique (Michie et al., 2013; if applicable)
Participants were taken to the research facility's community gym where exercises were demonstrated and practiced to show proper technique and to teach the function of each exercise.	4.1 Instructions on how to perform the behaviour 6.1 Demonstration of the behaviour 8.1 Behavioural practice
Weekly Coaching Sessions	
Participants' progress was monitored and feedback was provided	2.2 Feedback on behaviour 1.6 Discrepancy between current goal and behaviour
New goals were set when necessary	1.5 Review behavioural goal
Strategies were identified to address any new barriers	1.2 Problem solving
Strategy 1) Education: Exercise safety, instructions on how to perform PA, PA guidelines, benefits, PA behaviour change techniques and exercise video resources.	1.8 Behavioral contract 1.9 Commitment 2.2 Feedback on behavior 2.3 Self-monitoring of behavior 4.1 Instruction on how to perform a behavior 5.1 Information about health consequences 5.3 Information about social and environmental consequences 5.6 Information about emotional consequences 6.1 Demonstration of the behavior 7.1 Prompts/cues 8.1 Behavioral practice/ rehearsal 8.7 Graded tasks 10.2 Material reward (behavior) 10.4 Social reward 10.9 Self-reward 12.5 Adding objects to the environment 13.2 Framing/reframing
Strategy 2) Referral: Information on who to contact to address financial and transportation barriers, tips for finding local resources (e.g. gyms, programs, facilities), a list of key facilities, PA and sport organizations, professionals and resources to contact for SCI-specific PA information, and examples of ways to connect with peers or seek peer mentorship.	3.1 Social support (unspecified) 3.2 Social support (practical) 3.3 Social support (emotional) 13.1 Identification of self as role model
Strategy 3) Tailored PA prescription: Exercise training programs for the gym or home, information on how to adapt a gym or everyday equipment for exercise use, and enrolling in an adapted sport.	3.2 Social support (practical) 4.1 Instruction on how to perform a behavior 6.1 Demonstration of the behaviour 8.1 Behavioural practice 12.1 Restructuring the physical environment 12.4 Distraction

Note. Behaviour change techniques are coded using the Behaviour Change Technique Taxonomy (v1) (Michie et al., 2013)

Intervention behaviour change techniques and fidelity: Coaching sessions were audio recorded using a handheld digital recorder and transcribed verbatim to code for BCTs (Michie et al., 2013) and assess intervention content and fidelity. The intervention resource was coded using the Behaviour Change Technique Taxonomy V1 (Michie et al., 2013) to develop a coding manual for coding the coaching sessions. Thirty-six BCTs were included in the coding manual (see Appendix L for complete BCT list and link to evidence to support inclusion of BCTs). A research assistant coded each coaching session after completing a BCTTv1 online training program (http://www. Bct-taxonomy.com). A sample of transcripts (n=12; 10%) was double-coded to assess inter-rater coding reliability. Percent agreement was used to calculate reliability (Lorencatto, West, Bruguera, & Michie, 2014). Discrepancies were resolved through discussion between the two coders or through consultation with the senior author. The frequency of each BCT was used to describe the most commonly employed BCTs across sessions. To identify the proportion of session content that was not manual-specific, the percentage of the total number of BCTs delivered that were additional BCTs was calculated.

Wait-list control participants

Control participants completed baseline and post-intervention measures only. Following completion of post-intervention measures, they were administered the same PA coaching sessions as the intervention group.

Statistical analyses

Data were screened for missing values and outliers. No outliers or missing values unrelated to dropout were identified. Efficacy analyses were conducted; therefore, missing data for drop-outs (n=4) were not included in the analyses. Baseline group differences in gender, injury completeness (motor and sensory complete vs. incomplete), and level of injury (paraplegic vs. tetraplegic) were tested using Chi-square analyses. Group differences in baseline age, years post injury, aerobic fitness, HAPA constructs, and PA levels were tested using independent-samples t-tests. Exploratory ANCOVA analyses were conducted to examine the influence of commonly reported covariates on PA and fitness outcomes. Level of injury and years post-injury were not significant covariates for aerobic fitness. Likewise, when age, years post injury, gender, level of injury, and wear time (accelerometer only) were included in the PA analysis, no significant covariates were found. Between-group differences in PA, aerobic fitness, and HAPA constructs were examined using 2 (condition) x 2 (time: baseline and post) repeated measures ANOVAs. All repeated measures ANOVA assumptions were tested and confirmed. Effect sizes were calculated using Cohen's d, with values of 0.20, 0.50, and 0.80 representing small, medium, and large effects, respectively (Cohen, 1992).

Only the longest follow-up time point was included in the intervention condition analysis of changes in PA over time (for full results at all time points [baseline, week 4, week 7, post, 1, 2, 3, and 6-months follow-up] see Appendix M) to minimize missing data and maximize statistical power. One-way repeated measure ANOVAs with simple planned contrasts were conducted between baseline and week 4, week 7, and post-intervention self-reported PA and accelerometer-measured PA. Given existing evidence supporting increased levels of PA following intervention and at follow-up compared to baseline (Ma & Martin Ginis, 2018), planned contrasts were used instead of post hoc analyses. To examine changes in PA at follow-up, a one-way repeated measure ANOVA with simple planned contrasts was conducted between baseline, post-intervention, and 6-months follow-up on the self-reported PA measure.

4.3 Results

Participant flow

Figure 4 is a PRISMA flow diagram of participants from recruitment to the end of the 8-week intervention. Reasons for dropout (n=4) were unrelated to the study and included health issues (n=3) and lack of time (n=1). Two intervention group dropouts were replaced (two other participants dropped out after four weeks and therefore were not replaced). In total, 28 participants were randomly assigned to the intervention (n=14) and control (n=14) conditions and completed all baseline and post-intervention assessments. Two participants (one from each group) had complete tetraplegia and were unable to perform the incremental exercise test or wear the accelerometer; analyses for those measures were based on n=26.

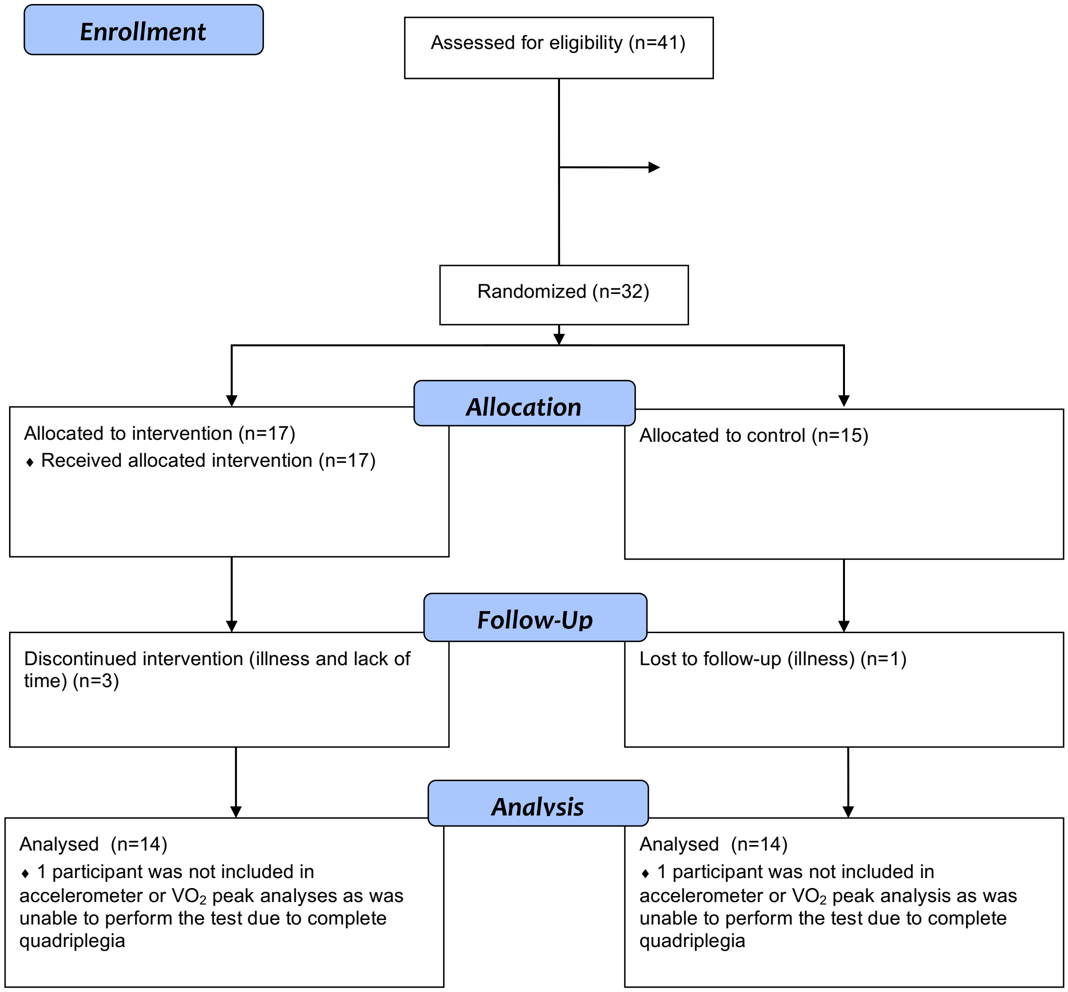

Figure 4. Study 3: CONSORT participant flow diagram

Participant characteristics and randomization check

Table 4 shows baseline demographic, PA, and aerobic fitness data. No significant differences were found between groups (p values >0.05) indicating participant randomization was successful.

Table 4. Study 3: Demographic characteristics and baseline physical activity

Variable	Intervention (n=14)	Control (n=14)	*p*
LTPAQ baseline MVPA (min/wk)	67.50±56.46	83.36±66.83	.50
Accelerometer Total VM	$5.62 \times 10^5 \pm 1.88 \times 10^5$	$8.48 \times 10^5 \pm 7.60 \times 10^5$	.21
Aerobic fitness (L/min)	1.15±.36	1.13±.46	.91
Years post injury	14.71±13.94	18.14±10.85	.47
Age (y)	45.79±13.63	45.57±10.49	.96
Female	5 (36%)	6 (43%)	1.00
Quadriplegia	5 (36%)	8 (57%)	.45
Paraplegia	9 (64%)	6 (43%)	.45
Complete injury (AIS A)	8 (57%)	7 (50%)	1.00

Note. Values are mean ± SD or n (%). MVPA=moderate to vigorous physical activity, VM=Vector Magnitude counts, AIS=American Spinal Injury Association Impairment Scale: a classification of A indicates no motor or sensory function below level of injury (a more severe injury).

Group differences in physical activity and aerobic fitness

Table 5 summarizes statistics for the LTPAQ and accelerometer data. There was a significant large-sized group x time effect of the intervention on LTPAQ total PA and MVPA. Participants in the intervention group performed, on average, four times more total PA and five times more MVPA than the control group post-intervention. Accelerometer-measured PA was also 17% greater in the intervention condition compared to the control condition with a significant small to medium-sized effect.

Table 5. Study 3: Means and standard deviations for self-reported and accelerometer-measured physical activity at baseline and post-intervention for control and intervention groups

	Baseline		Post								
Scale	Intervention (n=14)	Control (n=14)	Intervention (n=14)	Control (n=14)	F Group	*p* Group	F Time	*p* Time	F Group x Time	*p* Group x Time	*Cohen's d*
LTPAQ											
Total LTPA (min/wk)	163±118	180±136	420±372	110±109	4.94	.04	4.17	.05	13.14	**.001**	1.13
MV LTPA (min/wk)	68±57	83±67	280±309	48±69	4.79	.04	5.54	.03	10.79	**.003**	1.04
Accelerometer Total counts*	$5.62x10^5$± $1.88x10^5$	$8.48x10^5$± $7.59x10^5$	$7.02x10^5$± $2.67x10^5$	$5.98\ x10^5$± $3.90\ x10^5$	.34	.56	.37	.55	4.51	**.04**	.31

Note. Values are mean±SD. *Two participants did not wear the accelerometer, n=13 for each group for the accelerometer analysis. N=14 for each group for LTPAQ analyses. Effect sizes are for difference between intervention and control group post-intervention values. LTPA=leisure time physical activity; MV= moderate-vigorous

Table 6 summarizes statistics for the VO_{2peak} data. There was a medium to large-sized group x time effect of the intervention on absolute VO_{2peak} and peak power. Specifically, the intervention condition had a 13% and 7% increase in absolute VO_{2peak} and peak power respectively at post-intervention. In contrast, the control group decreased absolute VO_{2peak} by 6% and peak power by 7% at post-intervention.

Table 6. Study 3: Means and standard deviations for aerobic fitness at post-intervention for control and intervention groups

	Baseline		Post-intervention								
Variable	Intervention (n=14)	Control (n=14)	Intervention (n=14)	Control (n=14)	F Group	*p* Group	F Time	*p* Time	F Group x Time	*p* Group x Time	*Cohen's d*
Absolute VO_2 peak (L/min)	1.15±.36	1.13±.43	1.30±.43	1.06±.46	.67	.42	2.74	.11	19.30	**<0.001**	.54
Relative VO_2 peak (ml/kg/min)	15.94±4.24	15.00±5.72	17.83±4.91	13.94±5.47	1.48	.24	2.03	.17	25.37	**<0.001**	.94
Peak power (Watts)	81.67±27.06	69.71±37.02	87.22±29.68	64.97±34.21	1.80	.19	2.12	.11	17.56	**<0.001**	.68

Note. Values are mean±SD. Two participants were unable to complete the VO_2 peak test. Effect sizes are for difference between intervention and control groups at post-intervention.

Intervention group physical activity levels over time

Regarding self-reported PA, repeated measures ANOVA demonstrated that PA increased significantly over time within the intervention group (Table 7). Planned contrasts revealed significant differences between baseline and week 4, 7, and post-intervention, as well as between baseline and the 6-month follow-up for both total PA and MVPA. There was no significant difference between post-intervention and 6-months follow-up for MVPA nor total PA. Accelerometer-measured total vector magnitude counts were significantly greater between baseline and post-intervention only. Accelerometers were not used at follow-up time points.

Table 7. Study 3: Means and standard deviations for self-reported and accelerometer-measured physical activity at baseline, week 4, week 7, post-intervention, and 6-months follow-up for intervention condition only

Scale	Baseline	Week 4	Week 7	Post	6-month follow-up	F^a	p^a	F^b	p^b
LTPAQ									
Total LTPA (min/wk)	163±118	331±238*	337±198*	420±372*	348±269*	4.17	.01	5.24	.01
MV LTPA (min/wk)	68±57	260±180*	208±103*	289±319*	236±218*	5.62	.003	4.90	.02
Accelerometer Total counts	$5.62x10^5$± $1.88x10^5$	$5.93\ x10^5$± $3.07\ x10^5$	$6.59\ x10^5$± $3.38\ x10^5$	$7.02x10^5$± $2.67x10^5$*		1.39	.26		

Note. Values are mean±SD. *Indicates significantly different from baseline. a=tests of within subjects effects with baseline, week 4, week 7, and post-intervention included in the repeated measures ANOVA. b=tests of within subjects effects with baseline, post-intervention, and 6-months follow-up included in the repeated measures ANOVA. N=13 for baseline, week 4, week 7, and post-intervention analyses. N=12 for baseline, post-intervention, and 6-month follow-up analyses. LTPA=leisure time physical activity; MV= moderate-vigorous.

Health Action Process Approach model constructs

Table 8 summarizes results from the HAPA construct measure ANOVAs. No significant differences were found between groups for any of the baseline HAPA variables except knowledge which was significantly greater in the intervention than the control group (intervention=5.9±1.1; control=5.2±1.9, p=.012). Significant group x time effects were found for affective outcome expectancies, intentions, moderate and heavy aerobic self-efficacy, moderate and heavy strength self-efficacy, action planning, monitoring, social support, and knowledge in favour of the intervention condition. No significant group x time effects were observed for coping, planning, and barrier self-efficacy, risk perceptions, or barriers. Instrumental outcome expectancies and scheduling self-efficacy approached significance between groups post-intervention.

Table 8. Study 3: Means and standard deviations for Health Action Process Approach model constructs at baseline and post-intervention

	Baseline		Post-intervention								
Scale	Intervention (n=14)	Control (n=14)	Intervention (n=14)	Control (n=14)	F Group	p Group	F Time	*p* Time	F Group xTime	*p* Group xTime	*Cohen's d*
Pre-intention stage constructs											
Affective outcome expectancies	5.1±1.3	5.7±.9	5.6±1.0	5.4±1.0	.17	.68	.17	.68	9.26	**.005**	.19
Instrumental outcome expectancies	6.5±.6	6.5±.9	6.8±.3	6.3±.8	1.36	.25	1.0	.33	3.95	.06	.83
Risk perceptions	2.5±1.6	2.5±1.3	2.8±1.6	2.5±1.1	.04	.84	.21	.65	.21	.65	.22
Aerobic exercise task self-efficacy	3.4±1.9	4.1±1.7	4.7±1.2	3.6±1.6	.10	.76	2.31	.14	11.88	**.002**	.78
Strength exercise task self-efficacy	3.9±1.6	3.7±1.6	5.6±1.2	3.2±1.8	5.75	.02	5.90	.02	16.97	**<.001**	1.57
Intentions	6.1±1.1	6.5±.7	6.8±.4	6.3±1.2	.04	.85	1.56	.22	6.70	**.016**	.56

Scale	Baseline Intervention (n=14)	Baseline Control (n=14)	Post-intervention Intervention (n=14)	Post-intervention Control (n=14)	F Group	p Group	F Time	*p* Time	F Group xTime	Scale	Intervention (n=14)
Intention stage constructs											
Planning self-efficacy	5.9±.8	6.2±1.1	6.0±.5	6.8±.4	2.29	.16	2.51	.14	1.65	.23	-1.77
Barrier self-efficacy	5.0±1.2	4.4±1.0	5.7±.8	4.7±1.1	4.77	.04	5.17	.03	.92	.35	1.04
Scheduling self-efficacy	4.9±1.5	5.3±1.2	5.7±1.3	5.5±1.1	.04	.85	3.30	.08	1.79	**.06**	.16
Action planning	3.7±1.9	3.8±2.0	6.8±.4	3.6±2.3	9.36	.01	9.00	.006	12.79	**.001**	1.94
Action stage constructs											
Monitoring	4.5±1.6	4.4±1.4	6.3±.8	4.4±1.3	5.37	.03	11.28	.002	11.70	**.002**	1.76
Coping self-efficacy	6.0±.8	5.8±1.2	6.3±.7	6.3±.7	.09	.78	2.92	.12	.09	.77	0
Constructs relevant in all stages											
Social support	2.2±1.0	2.0±.8	2.8±.9	1.7±.5	7.32	.01	.37	.55	4.44	**.05**	1.50
Presence of barriers	5.7±1.5	5.5±1.3	6.1±1.1	5.0±1.8	1.56	.22	.01	.13	2.40	.13	.74
Knowledge	5.9±1.1	5.2±1.9	6.7±.4	4.4±2.0	9.32	.005	.02	.89	7.16	**.01**	1.59

Note. Values are mean±SD. Effect sizes are for differences between intervention and control group post-intervention values.

Intervention BCTs and fidelity

Average interrater reliability for coding the coaching sessions was 88%, which is considered high (>75%; Cohen, 1968). The most commonly delivered BCTs across sessions were feedback on behaviour, instructions on how to perform a behaviour, social support (emotional and practical), action planning, problem solving, information about health consequences, and reviewing behavioural goals. On average, 5.3±1.9 (range 1-10) BCTs were delivered per session with 26 unique BCTs delivered across all participants and sessions. Across all transcripts (n=123; 3 session transcriptions were missing), 99% of BCTs identified were included in the intervention manual. Additionally, all participants received BCTs that corresponded to each of the three key strategies (education, linking/referral, prescription), indicating high fidelity of delivery in practice.

4.4 Discussion

To our knowledge, the intervention produced the largest effects on self-reported leisure time PA of any published behavioural intervention RCT among people with physical disability (cf. Ma & Martin Ginis, 2018). This is also the first behavioural intervention to improve PA sufficiently to increase fitness among people with SCI. Furthermore, improvements in social cognitions regarding PA were also observed following this tailored and theory-based intervention that included PA education and behaviour change techniques, referral to other professionals and organizations, and exercise prescription.

Physical activity

The change in accelerometer-measured PA was small-medium (d=0.31), whereas, a very large effect was observed (d=1.13) for change in self-reported PA from pre- to post-intervention. The difference in effect sizes between accelerometer- and LTPAQ-measured PA is likely a result of the measures capturing different aspects of PA (Ma et al., 2018). Self-report is better for measuring the increased intensity and activity that occurs during lifting and inclined wheeling activities but is not detected by accelerometers (Bassett et al., 2000; Conger et al., 2015; Kooijmans et al., 2014). Accelerometry's second-by-second collection of data is sensitive to breaks in activity which can be difficult to recall using self-report (Shephard, 1967). These differences in measurement capabilities highlight the importance of using both accelerometer and self-report PA measures to accurately capture frequency, intensity, time, and type (FITT) of activity performed by people with SCI. The discrepancy between accelerometer- and self-reported PA may also in part be explained by accelerometers not capturing resistance training activities (Bassett et al., 2000) (which were a key prescription component of the intervention) as well as self-report limitations including recall bias (Shephard, 1967) and misclassification of perceived intensity (Brodin, Swardh, Biguet, & Opava, 2017; Martin Ginis, Latimer, Hicks, & Craven, 2005).

Nevertheless, results from the present study are similar to the largest effect sizes reported in non-randomized controlled trials of behavioural PA interventions in SCI. For example, in pre-post studies, Latimer et al. (2013) and Froehlich-Grobe and White et al. (2014) showed effect sizes of d=1.07 and d=1.05, respectively (Froehlich-Grobe et al., 2014; Latimer-Cheung et al., 2013). A meta-analysis of RCTs in people with physical disability showed the average effect size for change in self-reported PA behaviour following intervention was small-medium (g=0.35) with the largest being g=0.89 (Ma & Martin Ginis, 2018). Thus, the effects on PA in this study are impressive when compared to both non-randomized and randomized controlled trials in people with physical disability.

Further to the large effect sizes observed from baseline to immediately following the intervention, there was a maintenance of self-reported PA at 6-months follow-up. These findings are in line with the handful of studies that included follow-up measures and showed a maintenance of intervention effects on PA at 3 months (Wise et al., 2009) and 6 months (Froehlich-Grobe et al., 2014; Nooijen et al., 2016). A common theme between our intervention and previous interventions showing maintenance effects of PA was the inclusion of self-regulatory skills such as goal setting, self-monitoring, and problem solving. Control theory (Carver & Scheier, 1981) and findings from previous meta-analyses of effective BCTs (Ma & Martin Ginis, 2018; Michie, Abraham, Whittington, McAteer, et al., 2009) support the use of these techniques for identifying goals, monitoring progress, and correcting for disturbances from the goal to sustain the behaviour over time.

Cardiorespiratory fitness

Increases in PA were large enough to increase cardiorespiratory fitness. To our knowledge, this is the first study in people with SCI to demonstrate significant increases in both PA and cardiorespiratory fitness following a behavioural intervention. Furthermore, fitness improvements in the intervention group were double the 9% increase observed in an RCT in which the SCI fitness guidelines were implemented in a fully supervised exercise environment but without any additional BCTs (Pelletier, Totosy De Zepetnek, MacDonald, & Hicks, 2015). This difference in improvements suggests that although the BCT of providing instructions/prescriptions for performing PA can increase fitness, the use of additional BCTs is needed to get even larger increases in fitness.

In contrast, previous behavioural interventions have used BCTs such as action planning, goal setting, and problem solving to significantly increase PA, but did not improve fitness

(Froehlich-Grobe et al., 2014; Froehlich-Grobe & White, 2004; Nooijen et al., 2017; Radomski et al., 2011). In these studies, the specifics of the exercise sessions (beyond frequency, intensity, time and general type) were left to the participants. One distinct difference between our intervention and previous interventions is the use of *both* BCTs and a detailed exercise prescription. Theory-based BCTs like action planning and problem solving give participants the skills to self-manage their exercise on their own (Arbour-Nicitopoulos, Ginis, et al., 2009; Latimer et al., 2006). In addition, detailed exercise prescriptions are important because not knowing how to exercise is a commonly reported barrier in people with SCI (Scelza et al., 2005). In a sample of 72 individuals with chronic SCI, 80% felt having an exercise program would help them, emphasizing the utility of an exercise program to address this knowledge gap (Scelza et al., 2005). It may be necessary for the interventionist to give more details to improve fitness in behavioural interventions, such as information on specific exercises (e.g., lat pulldown, seated row), equipment, order of exercises, sets, repetitions, and intervals (details of a standard exercise program). Intervention condition participants received a tailored exercise program and reported almost perfect post-intervention knowledge scores on how to perform both aerobic and strength exercise. Provision of these specific exercise instructions in combination with BCTs that target HAPA constructs may explain the large, significant improvements in PA and fitness observed in the intervention.

Health Action Process Approach model constructs

Most HAPA constructs were strengthened in the intervention condition compared to the control condition. Specifically, affective outcome expectancies, intentions, moderate and heavy aerobic and strength self-efficacy, action planning, monitoring, social support, and knowledge were all significantly stronger compared to the control condition while improvements in instrumental outcome expectancies and scheduling self-efficacy approached significance. HAPA-based PA interventions, particularly those involving planning and action control, have been successful in strengthening social cognitions and increasing behaviour of people with chronic illness and disability (Schwarzer et al., 2011; Sniehotta, Scholz, Schwarzer, et al., 2005).

Constructs that were not significantly improved following the intervention included planning, barrier, and coping self-efficacy, barriers, and risk perceptions. Some of these non-significant changes may be explained by ceiling or floor effects. Specifically, coping and planning self-efficacy were already strong at baseline and participants did not view exercise to be harmful or a threat to triggering an episode of autonomic dysreflexia. These constructs were unlikely to change significantly in response to the intervention. The perceived presence of barriers did not change significantly between groups. This is likely because barriers were related to factors out of the control of the intervention such as weather, access to facilities, facilities being close, etc. Maintenance self-efficacy constructs have been shown to decrease following intervention as participants work through the challenges of maintaining behaviour (Arbour-Nicitopoulos, Martin Ginis, et al., 2009). The observed preservation of relatively high planning and barrier self-efficacy scores may actually signify a positive intervention effect. This study is the first RCT of an intervention employing the full HAPA model in people with SCI and results suggest the HAPA model is a useful theory for PA intervention design among people with SCI.

Integrated knowledge translation and intervention development

In addition to the HAPA model, an IKT approach to intervention development may have played a significant role in the intervention's success. Developing partnerships with those who "contend with the real-world needs and constraints of health systems" allows for the co-creation of knowledge that "in principle conveys the promise of significant social impact" (Jull, Giles, &

Graham, 2017, pg. 2). To have such significant impact in the PA context, our end-users taught us that changing PA behaviour is situational and dynamic and therefore requires tailoring to the individual over time. Resultantly, the intervention was designed to flexibly and responsively provide intervention strategies (education, referral, prescription) that address the individual's situation (e.g., preferences, resources, current levels of activity) and barriers (e.g., secondary complications, level of function, transportation issues, pain; Fekete & Rauch, 2012). A qualitative meta-synthesis of the experiences of people with physical disability in PA-enhancing interventions supports that flexibility in providing suitable PA options, and adapting to an individual's needs, substantially impacts participants' engagement with PA (Williams et al., 2017). Furthermore, acknowledging that issues experienced by people with disability differ not only from able-bodied individuals, but also between individuals with disability themselves reiterates the importance of tailoring interventions (Martin Ginis, Ma, & Stork, *in press*). Although tailoring may seem labour intensive, our intervention sessions were delivered in less than 15 minutes, once a week. Taking these points together, we believe that using an IKT approach to inform the development of a tailored, multi-faceted intervention was key to the success of the intervention improving PA and fitness.

Limitations

A few study limitations should be noted. First, it is unknown whether these findings extend to people living in non-urban centres; however, during the intervention development process, different environments (e.g., rural vs. urban) were taken into consideration and recommendations were made to address environmental barriers. Second, although having a researcher as the interventionist was a deliberate design decision to evaluate the efficacy of the intervention, its delivery by other interventionists has not been examined. The feasibility and acceptability of the intervention in the physiotherapist setting have been shown previously (Ma et al., under review), however, a study employing a physiotherapist interventionist is needed to confirm its effectiveness in practice. Third, it is uncertain whether the intervention is suitable for pre-intenders, as all but one participant was in the intender or actor phase. Lastly, we were not able to use individualized accelerometer cut-points to identify moderate intensity activity because of the variety of mobility modes used by our participants. Individualized cut-points may have increased the validity of accelerometer data. Only manual wheelchairs users have been evaluated for the use of an individualized cut-point, and our study involved people using a variety of mobility devices such as power chairs, smart drives, canes.

4.5 Summary

To our knowledge, the intervention produced the largest effect sizes for changes in PA and fitness of any behavioural intervention conducted in people with SCI to date (Ma & Martin Ginis, 2018). The effectiveness of the intervention in health and fitness professional settings (e.g., physiotherapy clinics, personal training gyms) needs to be tested; however, the brevity and efficacy of the intervention suggest it is a promising intervention for these settings. Given the success of the intervention, researchers are encouraged to use a combination of behaviour change theory and an IKT approach to increase the likelihood of intervention success.

Chapter 5: Conclusion

The general purpose of this dissertation was to advance physical activity (PA) measurement and intervention development in people with spinal cord injury (SCI) by 1) comparing the agreement, strengths and weaknesses of the most commonly used PA measures (accelerometers and the Physical Activity Recall Assessment for People with SCI [PARA-SCI]); and 2) using both integrated knowledge translation (IKT) and behaviour change theory for intervention development. Four main findings resulted from this dissertation. First, findings from Study 1 led to the recommendation that both self-report measures and accelerometers should be used to measure PA in people with SCI. Second, Study 2 demonstrated the use of both IKT and behaviour change theory to develop a PA intervention for people with SCI. Third, Study 2 demonstrated that this PA intervention is considered feasible for use in physiotherapy practice and its content can alleviate barriers to physiotherapist-led implementation of PA interventions (e.g., confidence, knowledge, resources). Fourth, Study 3 demonstrated that this PA intervention can improve both self-reported and accelerometer-measured PA, psychosocial predictors of PA, as well as fitness among people with SCI. The theoretical contributions, practical implications, limitations, and future directions are discussed in this final chapter.

5.1 Theoretical Contributions

This dissertation makes at least two theoretical contributions to IKT and health behaviour change.

5.1.1 Theoretical contribution #1: IKT and behaviour change theory can be integrated to develop interventions.

Theories identify *which* constructs to target (and for whom, dependent upon the theory), while the IKT process can determine *how* a construct is targeted. In other words, theory can be used to organize constructs to understand the processes by which changes in these constructs will lead to behaviour change. IKT can be used to identify intervention strategies that address barriers and are appropriate for the end-users' context. As examples, the HAPA model posits that barriers and resources have an important role for supporting behaviour change at all levels of motivation. Using an IKT process and the HAPA model to guide us, we identified barriers specific to the context (Study 2, Phases 1-3), suggested strategies to address these barriers (Study 2, Phases 2-4), and generated examples of helpful resources (Study 2, Phases 3-4). Likewise, the expert panel in Study 2, Phase 4 of the IKT process recommended the use of behavioural strategies (e.g., action planning, self-monitoring). The HAPA model organized these strategies which suggests they be used for those who have developed the intentions to exercise rather than those who have not developed intentions.

This combined use of IKT and behaviour change has implications for intervention developers looking to adopt a theory for a specific context. A strength of behaviour change theory is that it facilitates an understanding of what works by providing a *broad* framework that can be applied to different contexts (e.g., settings, populations, behaviours; Michie, Johnston, Francis, Hardeman, & Eccles, 2008). Using IKT can facilitate how that theory may be *specifically* applied to a particular setting, population, or behaviour. Thus, we recommend using behaviour change theory as the foundation for behaviour change and applying an IKT framework to tailor the specific strategies that target theoretical constructs when developing PA interventions for a given context.

Furthermore, an IKT process can be used to inform which behaviour change theory is most appropriate to use dependent upon the context. In Study 2, Phase 4, members of the expert panel noted that strategies need to be tailored to the individual's level of motivation. Additionally, they recommended that strategies that help people move from intention to behaviour, such as monitoring progress, setting goals, and overcoming barriers, were key to intervention success. Thus, the expert panel consultation component of the IKT process resulted in the decision to use the HAPA model as the guiding behaviour change theory for this intervention. When not guided by theory, how intervention content is selected has often been criticized for using ISLAGIAT (a term coined by Martin Eccles, Emeritus Professor of Clinical Effectiveness, for 'it seemed like a good idea at the time') principles, rather than theory. Likewise, how a theory itself is selected to guide intervention content can also fall subject to ISLAGIAT. Based on the theory selection that resulted in positive effects on PA in this dissertation, we recommend that engaging end-users in the process of selecting an appropriate theory for intervention development may be one solution to this limitation.

By combining behaviour change theory and IKT, intervention development is supported by theory that can be translated *across* contexts and can be tailored to the *specific* context. This is in line with recommendations from implementation experts and the Medical Research Council who endorse drawing upon theory to understand how behaviour change will occur and tailoring to the local context to maximize the potential fit of an intervention (Craig et al., 2008). Further, the results from Study 3 provide promising support for future intervention developers to use this integrated theoretical approach.

5.1.2 Theoretical contribution #2: The full HAPA model may be an effective behaviour change theory for designing interventions to increase PA among people with SCI.

To our knowledge, this is the first RCT in either a population with physical disability (Ma & Martin Ginis, 2018) or the able-bodied population (Gourlan et al., 2016) to have used the full HAPA model in PA intervention development. Previous studies have tested individual constructs of the HAPA model and have shown that strengthening these HAPA constructs can increase PA in people with SCI. For example, targeting action planning and coping planning, which are proposed to translate intentions into actions (Schwarzer et al., 2011), has been shown to significantly increase PA behaviour among people with SCI (Arbour-Nicitopoulos, Ginis, et al., 2009; Latimer et al., 2006). We demonstrated that beyond action planning and coping planning, other HAPA variables were strengthened following intervention including outcome expectancies, intentions, task self-efficacy, monitoring, social support, and knowledge. Although it was not explicitly compared, employing the full HAPA model led to larger PA effects than any other PA intervention targeting one or two constructs of the HAPA model among people with SCI (Arbour-Nicitopoulos, Ginis, et al., 2009; Latimer et al., 2006) as well as maintenance effects at six months.

These findings have implications for developing more effective interventions by demonstrating the utility of using the full HAPA model rather than one or two constructs from the model. By using the full HAPA model, a menu of intervention options was created that could be used as people's needs change over the course of adopting (and eventually maintaining) PA. Providing diverse interventions builds off recommendations from previous reviews. A meta-synthesis of participant perceptions of PA interventions among people with physical disability highlighted the need for interventions that are diverse enough to adapt to the needs of the individual (Williams et al., 2017). A systematic review of reviews of barriers to PA among people with physical disability suggested that multi-sectoral and multi-disciplinary interventions are likely needed to address the range in barriers people with physical disabilities face (Martin Ginis, Ma, Latimer-Cheung, & Rimmer, 2016). Based on the results of this dissertation, it is recommended that the full HAPA model be used in intervention development to address constructs that are important for behaviour change (e.g., knowledge, self-monitoring) and to provide the diversity of intervention strategies that are needed to address the plethora of PA barriers people with SCI face.

5.2 Practical implications

The results from this dissertation have at least five key practical implications for the PA, health behaviour change, and IKT research, as well as for physiotherapists, and people with SCI.

5.2.1 Practical implication # 1: Use both accelerometers and self-report when measuring PA among people with SCI.

Considering the strengths and weaknesses of measuring PA in people with SCI using either accelerometers or self-report, we recommend using both measures together. The validity and reliability of using both accelerometers and self-report PA measures concurrently was not explicitly examined in this dissertation; however, Study 3 demonstrated both accelerometers and the self-report measure were responsive to changes in PA between groups. We acknowledge that the two measures differed in PA effect size in Study 3. However, in Study 1, the wide limits of agreement between accelerometers and the PARA-SCI (Martin Ginis et al., 2005) for measuring PA performed in the community setting would suggest these differences are a result of the two measures capturing different components of PA. For example, people often reported resistance activity on the self-report Leisure Time Physical Activity Questionnaire (LTPAQ; Martin Ginis, Phang, Latimer, & Arbour-Nicitopoulos, 2012), but resistance exercise is not captured by accelerometers (Bassett et al., 2000). Likewise, people tend to over-estimate time playing sports because they don't include breaks in their recall (Martin Ginis et al., 2005; Shephard, 2003), however, accelerometers are sensitive to brief breaks in activity. Using both accelerometers and self-report offers unique information when interpreting PA data. Overall, the findings from Studies 1 and 3 suggest that having an objective measure of duration and a descriptive measure of the types of activity being performed provides a more comprehensive picture of the impact of PA interventions than when using either measure alone.

5.2.2 Practical implication # 2: An intervention to help improve PA during the transition from clinic to community for physiotherapists' clients with SCI.

This intervention has shown preliminary evidence of its suitability for use in practice. Results from Phase 2 in Study 2 demonstrated that the intervention content addressed physiotherapists' barriers to PA promotion and can improve perceived and tested knowledge, confidence, skills, and resources to deliver an SCI-specific PA intervention. Addressing barriers, combined with tested improved knowledge and confidence to promote PA, supports the potential for uptake and implementation once the intervention is disseminated more widely (Curran et al., 2008; Rea et al., 2004). Indeed, confidence has been shown to be the strongest predictor of whether a physiotherapist prescribes PA (Rea et al., 2004).

This intervention's content will be delivered through presentations and in-clinic training or the online resource can be used as a reference guide. Clients with SCI can also bring a printed version of the intervention to their physiotherapist or refer them to the online resource. As recommended by the expert panel, future work should also examine the role of other healthcare/exercise providers (e.g., kinesiologists, recreation therapists, occupational therapists, personal trainers) in delivering this PA intervention among people with SCI. For example, physiotherapists could refer clients to kinesiologists for exercise prescription, or to recreational therapists to connect with programs and facilities to integrate into the community. Referral to other healthcare/exercise providers could strengthen the continuum of care throughout the different stages of rehabilitation and community integration among individuals with SCI. Guided by the intervention developed in this dissertation, clients and physiotherapists (and in the future, other healthcare providers) can bring this research into practice and work together to prepare for the start or continuation of a physically active lifestyle during the transition from clinic to community.

5.2.3 Practical implication # 3: A template for multi-disciplinary and tailored PA interventions for individuals with SCI.

Because problems in health care are often complex, they require multi-disciplinary and end-user informed approaches (Bowen & Graham, 2013; Martin Ginis et al., 2016). This dissertation's approach to tailored PA intervention among people with SCI provides direction as to how the research, recreation sectors, and health care providers can collaborate to provide PA intervention solutions. It also provides direction for how to engage the end-user to develop tailored solutions all the way from development to uptake of the intervention.

A systematic review of barriers and facilitators to PA participation among people with physical disabilities put forth the recommendation for researchers, recreation providers, and health care providers to establish inter-professional communication channels and address the greater than 200, multi-level PA barriers people with physical disability experience. In doing so, strategies should not only focus on individuals with disability, but also on key stakeholders and interventionists (e.g., physiotherapists). The intervention developed in this dissertation provides a concrete example of how researchers, recreation providers, and health care providers can work collaboratively to improve PA among people with SCI. For example, the three overarching intervention themes of education, linking/referral, and prescription required the expertise of all three of these groups. Researchers provided the evidence for the physical activity guidelines and most effective behaviour change techniques; recreation providers offered appropriate programming, equipment, and staff support; and health care providers developed appropriate exercise prescriptions. Given the success of the intervention, we recommend researchers, health care providers, and recreation providers work together to provide multi-sectoral solutions to the numerous barriers to PA participation faced by people with physical disabilities (Martin Ginis et al., 2016).

End-users were also involved in the development of tailored interventions from start to finish. End-users were equal collaborators in intervention development (as described in Section 5.2.4) as well as in the final selection of their own intervention strategies in implementation. End-users were involved in the selection of their own intervention strategies by discussing their unique situation and barriers. An initial consultation explored their current levels of PA, goals, activity preferences, resources, and barriers to participation. This information was collaboratively updated through follow-up sessions where progress was monitored and barriers and strategies were reassessed to adapt to the dynamic needs of the individual to participate in PA. Flexibility in providing suitable PA options, and adapting to an individual's needs has been identified as positively influencing participants' responses to PA-enhancing interventions for people with disabilities (Williams et al., 2017). Furthermore, acknowledging that barriers experienced by people with disability differ not only from the barriers experienced by able-bodied individuals, but also differ between individuals with disability, highlights the importance of using tailored interventions (Martin Ginis, Ma, & Stork, 2017). This dissertation has developed and tested an intervention template that researchers, health care providers, and recreation providers can use to deliver multi-sectoral and tailored interventions to address physical inactivity.

5.2.4 Practical implication # 4: a model of how to engage two end-user groups in the KTA cycle process.

It has been recommended that researchers understand the specific needs of both knowledge users and interventionists when developing interventions (Graham et al., 2006). This recommendation is important as involvement of end-users has been shown to be the best predictor of the translation of research into practice (Curran et al., 2008). This project is the first to integrate the KTA into intervention development and to engage two end-user groups, knowledge users and interventionists, in the process. In Study 2 for example, both physiotherapists and people with SCI were involved in assessments of barriers to PA intervention and uptake, an expert panel that was integral to the design and review of the intervention prototype, evaluations of the effects of the intervention in their respective contexts (Study 3 for people with SCI), as well as informal consultations throughout the research process. Taken together, both knowledge users (people with SCI) and interventionists (physiotherapists) were engaged from problem identification to intervention evaluation.

It is likely that there are many other IKT methods for involving two end-user groups in intervention development. In fact, it's been suggested that there is no one strategy or template for engaging end-users in research (Bowen & Graham, 2013). Nevertheless, implementation scientists have called for concrete examples of engagement of end-users in research (Bowen & Graham, 2013). Through this dissertation, we have provided one example of end-user engagement using an IKT process (the KTA) where both the interventionist and knowledge user are equally considered.

5.2.5 Practical implication # 5: a model for rigorous and systematic intervention development.

A major shortcoming in complex interventions is that researchers do not fully define and develop interventions (Campbell et al., 2000; Eccles et al., 2005). The Medical Research Council made a call for the development of health-enhancing interventions to resemble the sequential phases of drug development (Campbell et al., 2000). Specifically, intervention developers should use theory and existing evidence as the foundation, identify intervention components through surveys or interviews, conduct exploratory trials to assess feasibility and acceptability, pilot-test outcome measures, and assess the efficacy through a randomized controlled trial (RCT) before full-scale implementation (Campbell et al., 2000; Eccles et al., 2005). Almost 20 years later, this approach to PA intervention development in people with disability has not been used.

Studies 1-3 were essentially a seven phase process to bring systematic rigour to intervention development, as recommended by the MRC. In sequential phases, Study 2 synthesized the evidence and theory in PA behaviour change interventions, identified intervention components through semi-structured interviews, a national survey, and an expert panel, and assessed the feasibility and acceptability of the intervention within interventionists. Study 1 pilot-tested the primary outcome of the intervention- PA measures. Study 3 examined the efficacy of the intervention through an RCT. Together, these sequential phases allowed us to fully define and develop our intervention, as the MRC recommended almost 20 years ago (Campbell et al., 2000). Given the demonstrated impact of the intervention developed in this dissertation, it is recommended that future intervention developers use a similar systematic and rigorous process to develop and refine interventions to ensure resources are used to support interventions that are most likely to be effective.

5.3 General limitations

While this dissertation has yielded recommendations for PA measurement in people with SCI and advanced an understanding of comprehensive PA intervention development using IKT and behaviour change theory, a few general limitations should be noted. First, we acknowledge there are other frameworks for engaging end-users that could have been selected rather than the KTA. Although we recommend that others apply the same framework, without testing different approaches, we can not conclude the KTA is the best framework to use in intervention development. Second, although Study 1 explored the advantages of combining the PARA-SCI and accelerometers for measuring PA, the LTPAQ was used instead of the PARA-SCI to measure PA in Study 3. The LTPAQ was chosen over the PARA-SCI as leisure time PA was the focus of the intervention and a weekly PA measure was preferred (the PARA-SCI measures 3 days) to match the measurement duration of the accelerometer. Nevertheless, as these measures are both self-report it is likely that the strengths and weaknesses found in Study 1 for the PARA-SCI also apply to the LTPAQ. Third, the intervention included 26 possible BCTs. It is likely that the intervention could be further distilled to focus on a core set of BCTs that are most effective. Moreover, the wide range of BCTs and intentional emphasis on tailoring also created challenges for assessing fidelity. The intervention was designed to deliver any, but not necessarily all, of the 26 BCTs dependent upon the individual's needs. Contrary to other interventions that may assess fidelity as the adherence to *all* prescribed BCTs with no additional BCTs (e.g., Lorencatto et al., 2014), fidelity to the current intervention was assessed by identifying additional BCTs as well as calculating adherence to the key groups of BCTs (i.e., education, linking/referral, prescription) among each individual.

5.4 Future directions

Many exciting areas of SCI research could stem from this dissertation as there is still ample room for improvement in PA measurement and intervention development. A gold standard for PA measurement in people with SCI remains to be developed. Further, this is the first attempt at developing a PA intervention for people with SCI using IKT and it resulted in the largest increases in PA and the only increases in fitness following a behavioural intervention. Our results beg the question, “what else can IKT teach us regarding intervention development?”.

Future studies should examine how to optimally combine self-report and accelerometer measures to provide more comprehensive PA data. One approach may be to validate the qualitative recommendations observed in Study 1 (e.g., accelerometers are limited in their ability to capture inclined wheeling or resistance training, self-report may over-estimate intensity and under-estimate periods of rest) against direct observation. Another important area of future research is to use IKT to develop a PA intervention that specifically focuses on pre-intenders. Most behavioural strategies have been developed for intenders (Eccles et al., 2005). Those who participated in the intervention development process were likely already motivated or interested in PA. More targeted engagement from those who are unmotivated or perhaps even unaware of the benefits of exercise are needed. Lastly, an RCT with physiotherapists as interventionists is needed to discern the effectiveness and generalizability of the intervention to the clinic setting. Following intervention, feedback should be sought from the physiotherapists and clients with SCI, sending the development process back to the beginning of the action phase of the KTA cycle to continually improve the intervention for its sustainable use.

As next steps for our research group, we will disseminate the intervention to physiotherapists and clients with SCI. This includes disseminating through our network of over

300 end-users that were engaged throughout the development process, 'lunch and learns' at hospitals, conference presentations, and inclusion of an online version of the intervention resource on the SCI Action Canada website. The intervention will be shared through provincial SCI organizations (e.g., SCI BC, SCI Ontario) to reach people with SCI so they can take ownership in their care as they work with their physiotherapist to facilitate the transition from clinic-based PA to community PA. Lastly, the intervention will be disseminated to research audiences through publication. In addition to the manuscripts included in this thesis, two further manuscripts will be written. A mixed methods paper on the effective intervention components will include results from the semi-structured interviews and BCT coding of the coaching sessions. The aim will be to identify the most important intervention components which can be translated to a more refined and concise intervention. A manuscript describing the effects of the intervention on cardiovascular health will also be written.

5.5 Summary

Considering the limited resources for addressing healthcare problems, substantial effort should be put toward optimal intervention development and evaluation before implementation (Eccles et al., 2005). This series of dissertation projects involved the evaluation of PA measures for people with SCI and utilized rigorous frameworks (KTA, HAPA, behaviour change wheel, behaviour change technique taxonomy AGREE-II) to develop a behavioural PA intervention for people with SCI. When tested in an RCT, the intervention yielded the largest effects on PA behaviour change that have been observed in any RCT conducted in people with living with physical disability. Overall, this dissertation highlights the utility of using rigorous, theory-based approaches for developing and evaluating PA interventions among people with SCI.

Bibliography

Arbour-Nicitopoulos, K. P., Martin Ginis, K. A., & Latimer, A. E. (2009). Planning, leisure-time physical activity, and coping self-efficacy in persons with spinal cord injury: A randomized controlled trial. *Archives of Physical Medicine and Rehabilitation*, *90*(12), 2003–2011. http://doi.org/10.1016/j.apmr.2009.06.019

Arbour-Nicitopoulos, K. P., Martin Ginis, K. A., Latimer-Cheung, A. E., Bourne, C., Campbell, D., Cappe, S., … Smith, K. (2013). Development of an evidence-informed leisure time physical activity resource for adults with spinal cord injury: the SCI Get Fit Toolkit. *Spinal Cord*, *51*(6), 491–500. http://doi.org/10.1038/sc.2013.7

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The Exercise of Control*. New York: W.H. Freeman & Co.

Bassett, D. R., Ainsworth, B. E., Swartz, A. M., Strath, S. J., Brien, W. L. O., & King, G. A. (2000). Validity of four motion sensors in measuring moderate intensity physical activity. *Medicine & Science in Sports & Exercise*, *2*(25), 471–480.

Bland, J. M., & Altman, D. G. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. *The Lancet*, *327*(8476), 307–310.

Borg, G. (1970). Perceived exertion as an indicator of somatic stress. *Scandinavian Journal of Rehabilitation Medicine*, *2*(2), 92–8.

Bouchard, C., & Shephard, R. J. (1994). Physical activity, fitness, and health: the model and key concepts. In *Physical Activity, Fitness, and Health: International Proceedings and Consensus Statement* (pp. 77–88).

Bowen, S., & Graham, I. D. (2013). Integrated knowledge translation. In S. E. Strauss, J. Tetroe,

& I. D. Graham (Eds.), *Knowledge Translation in Health Care: Moving from Evidence to Practice* (2nd ed.). Somerset, NJ: John Wiley & Sons.

Brodin, N., Swardh, E., Biguet, G., & Opava, C. (2017). Understanding how to determine the intensity of physical activity–An interview study among individuals with rheumatoid arthritis. *Disability and Rehabilitation*, *31*(6), 458–465. http://doi.org/10.1080/09638280802131853

Brouwers, M. C., Kho, M. E., Browman, G. P., Burgers, J. S., Cluzeau, F., Feder, G., … Zitzelsberger, L. (2010). AGREE II: Advancing guideline development, reporting and evaluation in health care. *Journal of Clinical Epidemiology*, *63*(12), 1308–1311. http://doi.org/10.1016/j.jclinepi.2010.07.001

Camden, C., Shikako-Thomas, K., Nguyen, T., Graham, E., Thomas, A., Sprung, J., … Russell, D. J. (2015). Engaging stakeholders in rehabilitation research: A scoping review of strategies used in partnerships and evaluation of impacts. *Disability and Rehabilitation*, *37*(15), 1390–1400. http://doi.org/10.3109/09638288.2014.963705

Campbell, M., Fitzpatrick, R., Haines, A., Kinmonth, A. L., Sandercock, P., Spiegelhalter, D., & Tyrer, P. (2000). Interventions To Improve Health, *321*(September).

Canadian Society for Exercise Physiologists, & Participaction. (2010). *Canadian physical activity guidelines*. Toronto, ON, Canada.

Carver, C., & Scheier, M. (1981). The self-attention-induced feedback loop and social facilitation. *Journal of Experimental Psychology*, *17*, 545–568.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126–131. http://doi.org/10.2307/20056429

Claydon, V. E., Hol, A. T., Eng, J. J., & Krassioukov, A. V. (2006). Cardiovascular responses and postexercise hypotension after arm cycling exercise in subjects with spinal cord injury. *Archives of Physical Medicine and Rehabilitation*, *87*, 1106–1114. http://doi.org/10.1016/j.apmr.2006.05.011

Cohen, J. (1968). Weighted kappa: Nominal scale agreement with provision for scaled disagreement or partial credit. *Psychological Bulletin*, *70*(4), 213–220.

Cohen, J. (1992). A Power Primer, (July).

Collins, E. G., Gater, D., Kiratli, J., Butler, J., Hanson, K., & Langbein, W. E. (2010). Energy cost of physical activities in persons with spinal cord injury. *Medicine and Science in Sports and Exercise*, *42*(4), 691–700. http://doi.org/10.1249/MSS.0b013e3181bb902f

Conger, S. A., Scott, S. N., Fitzhugh, E. C., Thompson, D. L., & Bassett, D. R. (2015). Validity of Physical Activity Monitors for Estimating Energy Expenditure During Wheelchair Propulsion, 1520–1526.

Conn, V. S., Hafdahl, A. R., Brown, S. A., & Brown, L. M. (2008). Meta-analysis of patient education interventions to increase physical activity among chronically ill adults, *70*, 157–172. http://doi.org/10.1016/j.pec.2007.10.004

Connell, L. A., Mcmahon, N. E., Redfern, J., Watkins, C. L., & Eng, J. J. (2015). Development of a behaviour change intervention to increase upper limb exercise in stroke rehabilitation, 1–9. http://doi.org/10.1186/s13012-015-0223-3

Cowan, R. E., Nash, M. S., & Anderson, K. D. (2013). Exercise participation barrier prevalence and association with exercise participation status in individuals with spinal cord injury. *Spinal Cord*, *51*(1), 27–32. http://doi.org/10.1038/sc.2012.53

Craig, P., Dieppe, P., Macintyre, S., Michie, S., & Nazareth, I. (2008). Developing and evaluating complex interventions: the new Medical Research Council guidance. *British Medical Journal*, *1655*(September), 1–6. http://doi.org/10.1136/bmj.a1655

Curran, G. M., Mukherjee, S., Allee, E., & Owen, R. R. (2008). A process for developing an implementation intervention: QUERI Series. *Implementation Science*, *11*, 1–11. http://doi.org/10.1186/1748-5908-3-17

Dejong, G., Tian, W., Hsieh, C., Junn, C., Karam, C., Ballard, P. H., … Backus, D. (2013). Rehospitalization in the first year of traumatic spinal cord injury after discharge from medical rehabilitation. *Archives of Physical Medicine and Rehabilitation*, *94*(4), S87–S97. http://doi.org/10.1016/j.apmr.2012.10.037

Donoghue, G. O., Doody, C., & Cusack, T. (2011). Physical activity and exercise promotion and prescription in undergraduate physiotherapy education: content analysis of Irish curricula. *Physiotherapy*, *97*(2), 145–153. http://doi.org/10.1016/j.physio.2010.06.006

Dryden, D. M., Saunders, L. D., Rowe, B. H., May, L. a, Yiannakoulias, N., Svenson, L. W., … Voaklander, D. C. (2003). The epidemiology of traumatic spinal cord injury in Alberta, Canada. *The Canadian Journal of Neurological Sciences. Le Journal Canadien Des Sciences Neurologiques*, *30*(2), 113–121.

Duran, F. S., Lugo, L., Ramı, L., & Eusse, E. (2001). Effects of an exercise program on the rehabilitation of patients with spinal cord injury. *Archives of Physical Medicine and Rehabilitation*, *82*, 1349–1354. http://doi.org/10.1053/apmr.2001.26066

Eccles, M., Grimshaw, J., Walker, A., Johnston, M., & Pitts, N. (2005). Changing the behavior of healthcare professionals : the use of theory in promoting the uptake of research findings, *58*, 107–112. http://doi.org/10.1016/j.jclinepi.2004.09.002

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191.

Fekete, C., & Rauch, A. (2012). Correlates and determinants of physical activity in persons with spinal cord injury: A review using the International Classification of Functioning, Disability and Health as reference framework. *Disability and Health Journal*, *5*(3), 140–50. http://doi.org/10.1016/j.dhjo.2012.04.003

Ferris, F. D., Gunten, C. F., & Emanuel, L. L. (2001). Knowledge: Insufficient for change. *Journal of Palliative Medicine*, *4*(2), 145–148.

Foulon, B. L., Lemay, V., Ainsworth, V., & Martin Ginis, K. A. (2012). Enhancing physical activity guidelines: A needs survey of adults with spinal cord injury and health care professionals. *Adapted Physical Activity Quarterly*, *29*(4), 329–345.

Froehlich-Grobe, K., Aaronson, L. S., Washburn, R. A., Little, T. D., Lee, J., Nary, D. E., … Norman, S. E. (2012). An exercise trial for wheelchair users: Project workout on wheels. *Contemporary Clinical Trials*, *33*(2), 351–363. http://doi.org/10.1016/j.cct.2011.10.014

Froehlich-Grobe, K., Lee, J., Aaronson, L., Nary, D. E., Washburn, R. A., & Little, T. D. (2014). Exercise for everyone: A randomized controlled trial of project workout on wheels in promoting exercise among wheelchair users. *Archives of Physical Medicine and Rehabilitation*, *95*(1), 20–28. http://doi.org/10.1016/j.apmr.2013.07.006

Froehlich-Grobe, K., & White, G. W. (2004). Promoting physical activity among women with mobility impairments: A randomized controlled trial to assess a home- and community-based intervention. *Archives of Physical Medicine and Rehabilitation*, *85*(April), 640–648. http://doi.org/10.1016/j.apmr.2003.07.012

Gibbons, R. S., Stock, C. G., Andrews, B. J., Gall, A., & Shave, R. E. (2016). The effect of FESrowing training on cardiac structure and function : pilot studies in people with spinal cord injury. *Nature Publishing Group*, *54*(10), 822–829. http://doi.org/10.1038/sc.2015.228

Gourlan, M., Bernard, P., Bortolon, C., Romain, A. J., Lareyre, O., Carayol, M., … Boiché, J. (2016). Efficacy of theory-based interventions to promote physical activity. A meta-analysis of randomised controlled trials. *Health Psychology Review*, *10*(1), 50–66. http://doi.org/10.1080/17437199.2014.981777

Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in Knowledge Translation : Time for a Map ?, *26*(1), 13–24. http://doi.org/10.1002/chp.47

Hicks, A. L., Martin Ginis, K. A., Pelletier, C. A., Ditor, D. S., Foulon, B., & Wolfe, D. L. (2011). The effects of exercise training on physical capacity, strength, body composition and functional performance among adults with spinal cord injury: a systematic review. *Spinal Cord*, *49*(11), 1103–1127. http://doi.org/10.1038/sc.2011.62

Hobbs, N., Godfrey, A., Lara, J., Errington, L., Meyer, T. D., Rochester, L., … Sniehotta, F. F. (2013). Are behavioral interventions effective in increasing physical activity at 12 to 36 months in adults aged 55 to 70 years? A systematic review and meta-analysis. *BMC Medicine*, *11*(1), 75. http://doi.org/10.1186/1741-7015-11-75

Huijg, J. M., Gebhardt, W. A., Crone, M. R., Dusseldorp, E., & Presseau, J. (2014). Discriminant content validity of a theoretical domains framework questionnaire for use in implementation research, 1–16.

Jacobs, P. L., & Nash, M. S. (2004). Exercise Recommendations for Individuals with Spinal Cord Injury, *34*(11), 727–751.

Jull, J., Giles, A., & Graham, I. D. (2017). Community-based participatory research and integrated knowledge translation: Advancing the co-creation of knowledge. *Implementation Science*, *12*(1), 1–9. http://doi.org/10.1186/s13012-017-0696-3

Kooijmans, H., Moremans, H., Stam, H., & Bussman, J. (2014). Valid detection of self-propelled wheelchair driving with two accelerometers. *Physiological Measurement*, *35*, 2297–2306. http://doi.org/10.1088/0967-3334/35/11/2297

Latimer-Cheung, A. E., Arbour-Nicitopoulos, K. P., Brawley, L. R., Gray, C., Justine Wilson, A., Prapavessis, H., … Martin Ginis, K. A. (2013). Developing physical activity interventions for adults with spinal cord injury. Part 2: Motivational counseling and peer-mediated interventions for people intending to be active. *Rehabilitation Psychology*, *58*(3), 307–15. http://doi.org/10.1037/a0032816

Latimer, A. E., Martin Ginis, K. A., & Arbour, K. P. (2006). The efficacy of an implementation intention intervention for promoting physical activity among individuals with spinal cord injury: A randomized controlled trial. *Rehabilitation Psychology*, *51*(4), 273–280. http://doi.org/10.1037/0090-5550.51.4.273

Letts, L., Martin Ginis, K. A., Faulkner, G., Colquhoun, H., Levac, D., & Gorczynski, P. (2011). Preferred methods and messengers for delivering physical activity information to people with spinal cord injury: a focus group study. *Rehabilitation Psychology*, *56*(2), 128–137. http://doi.org/10.1037/a0023624

Lorencatto, F., West, R., Bruguera, C., & Michie, S. (2014). A method for assessing fidelity of delivery of telephone behavioural support for smoking cessation. *Journal of Consulting and Clinical Psychology*, *82*(3), 482–491. http://doi.org/10.1037/a0035149

Lugo, L. H., Salinas, F., & García, H. I. (2009). Out-patient rehabilitation programme for spinal cord injured patients: Evaluation of the results on motor FIM score. *Disability and*

Rehabilitation, *29*, 873–881. http://doi.org/10.1080/09638280701455494

Ma, J. K., Cheifetz, O., Todd, K. R., Chebaro, C., Phang, S. H., Shaw, R. B., … Martin Ginis, K. A. (2018). Combining an integrated knowledge translation approach and behaviour change theory to develop a physiotherapist-delivered physical activity intervention for adults with spinal cord injury. *Under Review*.

Ma, J. K., & Martin Ginis, K. A. (2018). A meta-analysis of physical activity interventions in people with physical disabilities: Content, characteristics, and effects on behaviour. *Psychology of Sport & Exercise*.

Ma, J. K., McCracken, L. A., Voss, C., Chan, F. H. N., West, C. R., & Martin Ginis, K. A. (2018). Physical activity measurement in people with spinal cord injury: Comparison of accelerometry and self-report (Physical Activity Recall Assessment for People with Spinal Cord Injury). *Disability and Rehabilitation*.

Marcus, B., & Simkin, L. (1993). The stages of exercise behavior. *Journal of Sports Medicine and Physical Fitness*, *33*(1), 83–88.

Marino, R. J., Barros, T., Biering-Sorensen, F., Burns, S. P., Donovan, W. H., Graves, D. E., … Priebe, M. (2003). International standards for neurological classification of spinal cord injury. *The Journal of Spinal Cord Medicine*, *26*(sup1), S50–S56. http://doi.org/10.1080/10790268.2003.11754575

Martin Ginis, K. A., Arbour-Nicitopoulos, K. P., Latimer, A. E., Buchholz, A. C., Bray, S. R., Craven, B. C., … Wolfe, D. L. (2010). Leisure time physical activity in a population-based sample of people with spinal cord injury part II: Activity types, intensities, and durations. *Archives of Physical Medicine and Rehabilitation*, *91*(5), 729–733. http://doi.org/10.1016/j.apmr.2009.12.028

Martin Ginis, K. A., Hicks, A. L., Latimer, A. E., Warburton, D. E. R., Bourne, C., Ditor, D. S., … Wolfe, D. L. (2011). The development of evidence-informed physical activity guidelines for adults with spinal cord injury. *Spinal Cord*, *49*(11), 1088–1096. http://doi.org/10.1038/sc.2011.63

Martin Ginis, K. A., & Latimer-Cheung, A. E. (2016). Physical activity recall assessment for people with spinal cord injury (PARA-SCI): administration and scoring manual.

Martin Ginis, K. A., Latimer, A. E., Hicks, A. L., & Craven, B. C. (2005). Development and evaluation of an activity measure for people with spinal cord injury. *Medicine and Science in Sports and Exercise*, *37*(33), 1099–1111. http://doi.org/10.1249/01.mss.0000170127.54394.eb

Martin Ginis, K. A., Ma, J. K., Latimer-Cheung, A. E., & Rimmer, J. H. (2016). A systematic review of review articles addressing factors related to physical activity participation among children and adults with physical disabilities. *Health Psychology Review*. http://doi.org/10.1080/17437199.2016.1198240

Martin Ginis, K. A., Ma, J. K., & Stork, M. J. (2018). Exercise psychology issues for people with physical disabilities. In *APA Handbook of Sport and Exercise Psychology*.

Martin Ginis, K. A., Phang, S. H., Latimer, A. E., & Arbour-Nicitopoulos, K. P. (2012). Reliability and validity tests of the leisure time physical activity questionnaire for people with spinal cord injury. *Archives of Physical Medicine and Rehabilitation*, *93*(4), 677–682. http://doi.org/10.1016/j.apmr.2011.11.005

Martin Ginis, K. A., van der Scheer, J. W., Latimer-Cheung, A. E.; Borrow, A., Bourne, C., Carruthers, P., …Goosey-Tolfrey, V. L. (2017). Evidence-based scientific exercise guidelines for adults with spinal cord injury: an update and a new guideline. *Spinal Cord*, 1–13. http://doi.org/10.1038/s41393-017-0017-3

Martin Ginis, K. A., Tomasone, J. R., Latimer-Cheung, A. E., Arbour-Nicitopoulos, K. P., Bassett-Gunter, R. L., & Wolfe, D. L. (2013). Developing physical activity interventions for adults with spinal cord injury. Part 1: A comparison of social cognitions across actors, intenders, and nonintenders. *Rehabilitation Psychology*, *58*(3), 299–306. http://doi.org/10.1037/a0032815

Martin Ginis, K.A., Jetha, A., Mack, D. E., & Hetz, S. (2009). Physical activity and subjective well-being among people with spinal cord injury: A meta-analysis. *Spinal Cord*, *48*(1), 65–72. http://doi.org/10.1038/sc.2009.87

Ginis, K. A. M., Latimer, A. E., Hicks, A. L., & Craven, B. C. (2005). Development and evaluation of an activity measure for people with spinal cord injury. *Medicine and Science in Sports and Exercise*, *37*(7), 1099–1111. http://doi.org/10.1249/01.mss.0000170127.54394.eb

Martin Ginis, K.A., Tomasone, J. R., Latimer-Cheung, A. E., Arbour-Nicitopoulos, K. P., Bassett-Gunter, R. L., & Wolfe, D. L. (2013). Developing physical activity interventions for adults with spinal cord injury. Part 1: a comparison of social cognitions across actors, intenders, and nonintenders. *Rehabilitation Psychology*, *58*(3), 299–306. http://doi.org/10.1037/a0032815

Maynard, F. M., Bracken, M. B., Creasey, G., Ditunno, J. F., Donovan, W. H., Ducker, B., … Wilberger, J. E. (1997). International standards for neurological and functional classification of spinal cord injury: American Spinal Injury Association. *Spinal Cord*, *35*,

McCracken, L. A., Ma, J. K., Voss, C., Chan, F. H., Martin Ginis, K. A., & West, C. R. (2018). Wrist accelerometry for physical activity measurement in individuals with spinal cord injury: A need for individually calibrated cut-points. *Archives of Physical Medicine and Rehabilitation*, *99*(4), 684–689. http://doi.org/10.1016/j.apmr.2017.10.024

Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology*, *28*(6), 690–701. http://doi.org/10.1037/a0016136

Michie, S., Atkins, L., & West, R. (2014). *The behaviour change wheel: a guide to designing interventions*. Great Britain: Silverback Publishing.

Michie, S., Johnston, M., Francis, J., Hardeman, W., & Eccles, M. (2008). From theory to intervention: Mapping theoretically derived behavioural determinants to behaviour change techniques. *Applied Psychology*, *57*(4), 660–680. http://doi.org/10.1111/j.1464-0597.2008.00341.x

Michie, S., & Prestwich, A. (2010). Are interventions theory-based? Development of a theory coding scheme. *Health Psychology*, *29*(1), 1–8. http://doi.org/10.1037/a0016939

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., … Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine*, *46*(1), 81–95. http://doi.org/10.1007/s12160-013-9486-6

Miller, L. E., & Herbert, G. (2016). Health and economic benefits of physical activity for patients with spinal cord injury, 551–558.

Nash, M. S. (2005). Exercise as a health-promoting activity following spinal cord injury. *Journal of Neurologic Physical Therapy : JNPT*, *29*(2), 87–103, 106.

Nightingale, T. E., Rouse, P. C., Thompson, D., & Bilzon, J. L. J. (2017). Measurement of physical activity and energy expenditure in wheelchair users: Methods, considerations and future directions. http://doi.org/10.1186/s40798-017-0077-0

Nooijen, C. F. J., Stam, H. J., Bergen, M. P., Bongers-Janssen, H. M. H., Valent, L., van Lageveld, S., … van den Berg-Emons, R. J. G. (2016). A behavioural intervention increases physical activity in people with subacute spinal cord injury: A randomised trial. *Journal of Physiotherapy*, *62*(1), 35–41. http://doi.org/10.1016/j.jphys.2015.11.003

Nooijen, C. F. J., Stam, H. J., Sluis, T., Valent, L., Twisk, J., & Van Den Berg-Emons, R. J. G. (2017). A behavioral intervention promoting physical activity in people with subacute spinal cord injury: Secondary effects on health, social participation and quality of life. *Clinical Rehabilitation*, *31*(6), 772–780. http://doi.org/10.1177/0269215516657581

Noonan, V. K., Fingas, M., Farry, A., Baxter, D., Singh, A., Fehlings, M. G., & Dvorak, M. F. (2012). Incidence and prevalence of spinal cord injury in Canada: A national perspective. *Neuroepidemiology*, *38*(4), 219–226. http://doi.org/10.1159/000336014

Noreau, L., Shephard, R. J., Simard, C., Pare, G., & Pomerleau, P. (1993). Relationship of impairment and functional ability to habitual activity and fitness following spinal cord injury. *International Journal of Rehabilitation Research*, *16*, 265–275.

Pelletier, C. A., Totosy De Zepetnek, J. O., Macdonald, M. J., & Hicks, A. L. (2015). A 16-week randomized controlled trial evaluating the physical activity guidelines for adults with spinal cord injury. *Spinal Cord*, *53*(5), 363–367. http://doi.org/10.1038/sc.2014.167

Prince, S., Adamo, K., Hamel, M., Hardt, J., Gorber, S., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *The International Journal of Behavioral Nutrition and Physical Activity*, *5*, 56. http://doi.org/10.1186/1479-5868-5-56

Prochaska, J. O., & DiClemente, C. C. (2005). The transtheoretical approach. In J. C. Norcross & M. R. Goldfried (Eds.), *Handbook of psychotherapy integration. Oxford series in clinical psychology* (2nd ed., pp. 147–171). New York: Oxford.

Radomski, M. V., Finkelstein, M., Hagel, S., Masemer, S., Theis, J., & Thompson, M. (2011). A pilot wellness and weight management program for individuals with spinal cord injury: Participants' goals and outcomes. *Topics in Spinal Cord Injury Rehabilitation*, *17*(2), 59–69. http://doi.org/10.1310/sci1702-59

Rea, B. L., Marshak, H. H., Neish, C., & Davis, N. (2004). The role of health promotion in physical therapy in California, New York, and Tennessee. *Physical Therapy*, *84*(6), 510–523.

Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annual Review of Psychology*, *52*, 141–166.

Sallis, J. F., Grossman, R. M., Pinski, R. B., Patterson, T. L., & Nader, P. R. (1987). The development of scales to measure social support for diet and exercise behaviours. *Preventive Medicine*, *16*, 825–836.

Scelza, W. M., Kalpakjian, C. Z., Zemper, E. D., & Tate, D. G. (2005). Perceived barriers to exercise in people with spinal cord injury. *American Journal of Physical Medicine & Rehabilitation*, *84*(8), 576–583. http://doi.org/10.1097/01.phm.0000171172.96290.67

Schoeller, D. A., & van Santen, E. (1982). Measurement of energy expenditure in humans by doubly labeled water method. *Journal of Applied Physiology*, *53*(4), 955–959.

Scholz, U., Sniehotta, F. F., & Schwarzer, R. (2005). Predicting physical exercise in cardiac rehabilitation: The role of phase-specific self-efficacy beliefs. *Journal of Sport and Exercise Psychology*, *27*(2), 135–151.

Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology*, *57*(1), 1–29. http://doi.org/10.1111/j.1464-0597.2007.00325.x

Schwarzer, R., Lippke, S., & Luszczynska, A. (2011). Mechanisms of health behavior change in persons with chronic illness or disability: The Health Action Process Approach (HAPA). *Rehabilitation Psychology*, *56*(3), 161–170. http://doi.org/10.1037/a0024509

SCI Action Canada. (2011). *Physical Activity Guidelines for Adults with Spinal Cord Injury*.

Shephard, R. J. (1967). Normal levels of activity in Canadian city dwellers. *The Canadian Medical Association Journal*, *97*(7), 313–318.

Shephard, R. J. (2003). Limits to the measurement of habitual physical activity by questionnaires.

Shirley, D., van der Ploeg, H. P., & Bauman, A. E. (2010). Physical activity promotion in the physical therapy setting: perspectives from practitioners and students. *Physical Therapy*, *90*(9), 1311–22. http://doi.org/10.2522/ptj.20090383

Sinden, K., & MacDermid, J. C. (2014). Does the knowledge-to-action (KTA) framework facilitate physical demands analysis development for firefighter injury management and return-to-work planning? *Journal of Occupational Rehabilitation*, *24*(1), 146–159. http://doi.org/10.1007/s10926-013-9442-0

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychology & Health*, *20*(2), 143–160. http://doi.org/10.1080/08870440512331317670

Sniehotta, F. F., Scholz, U., Schwarzer, R., Fuhrmann, B., Kiwus, U., & Völler, H. (2005). Long-term effects of two psychological interventions on physical exercise and self-regulation following coronary rehabilitation. *International Journal of Behavioral Medicine*, *12*(4), 244–55. http://doi.org/10.1207/s15327558ijbm1204_5

Sniehotta, F., Scholz, U., Lippke, S., Ziegelmann, J., & Luszczynska, A. (2002). Scale for the assessment of phase-specific self-efficacy of physical activity. *Health Psychology*.

Strauss, S. E., Tetroe, J., & Graham, I. D. (2013). Knowledge translation: What it is and what it isn't. In *Knowledge Translation in Health Care: Moving from Evidence to Practice* (2nd ed., pp. 3–13). Chichester, West Sussex: John Wiley & Sons.

Tanhoffer, R. A., Tanhoffer, A. I. P., Raymond, J., Hills, A. P., & Davis, G. M. (2012). Comparison of methods to assess energy expenditure and physical activity in people with spinal cord injury. *Journal of Spinal Cord Medicine*, *35*(1), 35–45. http://doi.org/10.1179/2045772311Y.0000000046

Taylor, N., Conner, M., & Lawton, R. (2012). The impact of theory on the effectiveness of worksite physical activity interventions: a meta-analysis and meta-regression. *Health Psychology Review*, *6*(December), 33–73. http://doi.org/10.1080/17437199.2010.533441

Taylor, P., Rimmer, J., Lai, B., Rimmer, J., & Lai, B. (2015). Framing new pathways in transformative exercise for individuals with existing and newly acquired disability Framing new pathways in transformative exercise for individuals with existing and newly acquired disability, (August). http://doi.org/10.3109/09638288.2015.1047967

Taylor, S. J., Pinnock, H., Epiphaniou, E., Pearce, G., Parke, H. L., Schwappach, A., … Sheikh, A. (2014). A rapid synthesis of the evidence on interventions supporting self-management for people with long-term conditions: PRISMS – Practical systematic RevIew of Self-Management Support for long-term conditions. *Health Services and Delivery Research*, *2*(53), 1–580. http://doi.org/10.3310/hsdr02530

Tomasone, J. R., Flood, S. M., Ma, J. K., Scime, N. V, Burke, S. M., Sleeth, L., … The SCIRE Research Team. (2018). Physical activity self-management interventions for adults with spinal cord injury: Part 1–A systematic review of the use and effectiveness of behavior change techniques. *Psychology of Sport & Exercise*. http://doi.org/10.1016/j.psychsport.2018.01.012

Tomasone, J. R., Wesch, N. N., Martin Ginis, K. A., & Noreau, L. (2013). Spinal Cord Injury , Physical Activity , and Quality of Life : A Systematic Review, 113–129.

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & Mcdowell, M. (2007). Physical activity in the United States measured by accelerometer. *Medicine & Science in Sports & Exercise*, 181–188. http://doi.org/10.1249/mss.0b013e31815a51b3

van den Berg-Emons, R. J., Bussmann, J. B., & Haisma, J. A. (2008). A prospective study on physical activity levels after spinal cord injury during inpatient rehabilitation and the year after discharge. *Archives of Physical Medicine and Rehabilitation*, *89*, 2094–2101. http://doi.org/10.1016/j.apmr.2008.04.024

van den Berg-Emons, R. J., Bussmann, J. B., & Stam, H. J. (2010). Accelerometry-based activity spectrum in persons with chronic physical conditions. *Archives of Physical Medicine and Rehabilitation*, *91*(12), 1856–1861. http://doi.org/10.1016/j.apmr.2010.08.018

van der Scheer, J. W., Martin Ginis, K. A., Ditor, D. S., Goosey-Tolfrey, V. L., Hicks, A. L., West, C. R., & Wolfe, D. L. (2017b). Effects of exercise on fitness and health of adults with spinal cord injury. *Neurology*.

Warms, C. A., & Belza, B. L. (2004). Actigraphy as a measure of physical activity for wheelchair users with spinal cord injury. *Nursing Research*, *53*(2), 136–143.

Warms, C. A, Belza, B. L., Whitney, J. D., Mitchell, P. H., & Stiens, S. A. (2007). Lifestyle physical activity for individuals with spinal cord injury: a pilot study. *American Journal of Health Promotion*, *18*(4), 288–291.

Webb, T. L., Joseph, J., Yardley, L., & Michie, S. (2010). Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of Medical Internet Research*, *12*(1), 1–18. http://doi.org/10.2196/jmir.1376

Whiteneck, G., Gassaway, J., Dijkers, M., Backus, D., Charlifue, S., Chen, D., … Smout, R. J. (2011). The SCIRehab project: treatment time spent in SCI rehabilitation. Inpatient treatment time across disciplines in spinal cord injury rehabilitation. *The Journal of Spinal Cord Medicine*, *34*(2), 133–148. http://doi.org/10.1179/107902611X12971826988011

Williams, T. L., Ma, J. K., & Martin Ginis, K. A. (2017). Participant experiences and perceptions of physical activity-enhancing interventions for people with physical impairments and mobility limitations: a meta-synthesis of qualitative research evidence. *Health Psychology Review*, *11*(2), 179–196. http://doi.org/10.1080/17437199.2017.1299027

Wise, H. H., Jackson Thomas, K., Nietert, P. J., Brown, D. D., Sword, D. O., & Diehl, N. (2009). Home Physical Activity Programs for the Promotion of Health and Wellness in Individuals with Spinal Cord Injury. *Topics in Spinal Cord Injury Rehabilitation*, *14*(4), 122–132. http://doi.org/10.1310/sci1404-122

Zbogar, D., Eng, J. J., Miller, W. C., Krassioukov, A. V, & Verrier, M. C. (2016). Reliability and validity of daily physical activity measures during inpatient spinal cord injury rehabilitation. http://doi.org/10.1177/2050312116666941

Appendices

Appendix A. Study 1: Physical Activity Recall Assessment for People with Spinal Cord Injury

For each activity, indicate: 1. Duration (min) 2. Intensity Mild=mild, Mod=moderate, Heavy = heavy, NNA = nothing at all 3. Type: ADL, LTPA

Be sure to record the date			**DATE :**				**DATE :**				**DATE :**			
			Activity	Intensity	Min	Type	Activity	Intensity	Min	Type	Activity	Intensity	Min	Type
Morning Routine	Wake Up Time													
	Transfer													
	Bowel and Bladder Management													
	Bathing													
	Personal Hygeine													
	Dressing	Lower Body												
		Upper Body												
	Other													

Latimer *et al.* Medicine & Science in Sports & Exercise. 38(2):208-216, February 2006.

Be sure to record the date	**DATE :**				**DATE :**				**DATE :**			
	Activity	Intensity	Min	Type	Activity	Intensity	Min	Type	Activity	Intensity	Min	Type
Breakfast												
Morning												
Lunch												
Afternoon												
Dinner												
Evening												

Latimer *et al.* Medicine & Science in Sports & Exercise. 38(2):208-216, February 2006.

Be sure to record the date			DATE :				DATE :				DATE :			
			Activity	Intensity	Min	Type	Activity	Intensity	Min	Type	Activity	Intensity	Min	Type
Evening Routine	Bedtime													
	Transfer													
	Bowel and Bladder Management													
	Bathing													
	Personal Hygeine													
	Dressing	Lower Body												
		Upper Body												
	Positioning													
	Other													

Latimer *et al.* Medicine & Science in Sports & Exercise. 38(2):208-216, February 2006.

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Appendix B. Study 2: AGREE-II items

AGREE II Item	Modified AGREE II Item	Application to the toolkit
1. The overall objective of the guideline is specifically described	The overall objective of the intervention is specifically described	To develop a theory-based intervention that will be conducted by physiotherapists to support their clients with SCI to participate in PA. **[manuscript abstract]**
2. The health question covered by the guideline is specifically described	The practical steps for implementing the intervention are specifically described	To produce recommendations for the format and content of an evidence-based toolkit for PT based PA promotion for clients with SCI; to produce recommendations for the dissemination of the toolkit **[meeting- exec summary]**
3. The population to whom the guideline is meant to apply is specifically described	The population to whom the intervention is meant to apply is specifically described	In-patient physiotherapists, out-patient physiotherapists, private practice physiotherapists; people with SCI **[meeting- exec summary]**
4. The guideline development group includes individuals from all relevant professional groups	The expert panel includes individuals from all relevant professional groups	5 consumers with SCI; 5 physiotherapists (in/out-patient; private practice); 1 physiatrist; 2 behaviour change researchers)
5. The views and preferences of the target population have been sought	Original AGREE II items retained	Expert panel included end-users of the intervention. Recommendations were provided based on previous research [1-5]; informant interviews with consumers with SCI (n=26); national survey of PTs (n=239).
6. The target users of the guideline have been sought	The target users of the intervention are clearly defined	In- patient physiotherapists, out-patient physiotherapists, private-practice physiotherapists; people with SCI **[meeting- exec summary]**
7. Systematic methods were used to search for evidence	Original AGREE II Item retained	Research was conducted and/or evidence was gathered by project leads (e.g., 2 systematic reviews [1,2], 1 meta-analysis [3], SCI PAG [4], SCI Get Fit Toolkit [5] **[p.4 toolkit]**
8. The criteria for selecting the evidence are clearly described	Original AGREE II Item retained	Minimal SCI specific literature to evaluate, therefore a mixture of SCI-specific and general physical disability evidence was provided to expert panel [1-5]. **[p.9]**
9. The strengths and limitations of the body of evidence are clearly described	Original AGREE II Item retained	Strengths and limitations of systematic reviews [1,2] were described to the expert panel; The generalizability of evidence may not have been entirely SCI-specific.
10. The methods for formulating the recommendations are clearly described	Original AGREE II Item retained	A multistep process was used: 1) panel members reviewed evidence prior to panel meeting; 2) a summary of key-points from evidence base was provided to panel members during the meeting; 3) structured break out/group discussions; 4) review and revision of recommendations
11. The health benefits, side effects and risks have been considered in formulating the recommendations	The practical implications have been considered in developing the intervention	PTs may gain increased knowledge, skills, confidence (etc.) to promote PA to people with SCI; this tool may help transition people with SCI from intentions to action for PA participation
12. There is an explicit link between the recommendations and the supporting evidence	Original AGREE II Item retained	1.References to evidence base were formulated; 2. A reviewer external to the expert panel

		examined the evidence base to ensure recommendations were supported by literature.
13. The guideline has been externally reviewed by experts before its publication	Recommendations included in the intervention/toolkit have been externally reviewed by experts prior to its publication	Toolkit content and format recommendations were reviewed and revised by panel members (n=13) and pilot tested by PTs external to the panel (n=20).
14. A procedure for updating the guideline is provided	A procedure for updating the intervention is provided	Plans to update the guideline following implementation with PTs/people with SCI were discussed (Phase 5);
15. The recommendations are specific and unambiguous	Original AGREE II Item retained	Recommendations for intervention were considered to be affordable, practicable, effective, acceptable, had no safety concerns, equally beneficial for PTs in various settings (Phase 5) **(p.15)**
16. The different options for management of the condition or health issue are clearly presented	The different options for dissemination of the intervention are clearly presented	**Manuscript p 18:** *Physiotherapists*: presentations; in-clinic training; quick-reference guide; update PT educational curriculum. *Clients with SCI*: provide PT with printed version
17. Key recommendations are easily identifiable	Key recommendations/guidelines are easily recognizable	Educate; Link and Refer; Tailored Prescription (**Cheat Sheet);** Results from semi-structured interviews following RCT with PTs support recommendations being easily identifiable
18. The guideline describes facilitators and barriers to its application	The intervention describes facilitators and barriers to its application/dissemination	Dissemination strategies were modified based on expert panel recommendations (i.e., initially target SCI-specific rehab centres; target community based PTs; will require increased financial resources)
19. The guideline provides advice and/or tools on how the recommendations can be put into practice	The recommendations/guidelines provide advice on how the toolkit can be put into practice	Educate; Link and Refer; Tailored Prescription (**Cheat Sheet**); Have respected PTs with experience working with clients with SCI to promote use of toolkit in daily practice
20. The potential resource implications of applying the recommendations have been considered	The potential resource implications of disseminating/implementing the toolkit have been considered	Greater demand for time of PTs to spend with clients; printing; updating PT educational curriculum
21. The guideline presents monitoring and/or auditing criteria	Strategies for monitoring and/or updating the toolkit have been considered	Downloads can be monitored from SCI Action Canada; contact information provided for recommended updates; no further funding opportunities have been presented for additional monitoring of toolkit uptake
22. The views of the funding body have not influenced the content of the guideline	The views of the funding body have not influenced the content of the intervention	Funding body representatives did not partake in the Expert Panel/development of recommendations
23. Competing interests of guideline development group members have been recorded and addressed	Competing interests of expert panel members have been recorded and addressed	None of the panel members reported any conflicts of interest

Appendix C. Study 2: Key informant interview with people with SCI

Physiotherapist Support for Physical Activity (Open ended):

1. How has your PT helped you (if at all) to participate in physical activity outside of the clinic?

2. Did they do anything that wasn't helpful, if so, what?

3. How could/could have your physiotherapist better support/ed you to become more physically active?

Appendix D. Study 2: Key informant interview responses

Interview Responses from Participants with SCI (n=28): Preferences for the Role of the Physiotherapist in Promoting Physical Activity

Table 1-3. Theme and number of respondents supporting the theme

Table 1. Did your physiotherapist do anything that was not helpful?

Nothing their PT did that was not helpful	15	Needed tailoring	1
Treatment inhibited function	3	Not providing encouragement	1
Not enough time	1	Lacking knowledge for exercise and prescription	1
Needed to work on functions for ADLs first	1	Not enough emphasis on exercise	1
Too easy	1	Did not foster autonomy	1

Table 2. How has your physiotherapist in the past helped you (if at all) to participate in physical activity outside of the clinic?

Encouragement/ motivation	9	Challenged them	2
Introduced to other athletes	4	Discussed benefits/consequences	2
Trained/ encouraged to compete in sport	3	Made equipment recommendations	1
Referred to local programs	3	Increased confidence	1
Made/ recommended adaptations	3	Accompanied to new program	1
Gave exercise ideas	3	Provided access to exercise facility	1
Prescribed exercise	2	Provided sport specific therapy	1
Taught transferrable skills	2	Monitoring	1

Table 3. How could/ could have your physiotherapist better support/ed you to become more physically active?

Program/ facility referral	14	Education on adaptations	1
Connect with peers	7	Monitoring	1
Tailoring/ asking client what they want	7	Coping planning	1
Education on financial support	4	Goal setting	1
Prescribing exercise	3	Set limits to avoid harm	1
Encouragement	3	Accompany to program	1
Education (general)	2	Transferrable skills	1
Education on benefits	2	Attend to self-management first	1
Introduction to a variety of sports	2	Challenge	1
Collaboration with other HCP	2	Integrate PT reach into community	1
Encourage to try new things	2	Novel exercise	1
Holistic approach- PA and diet	2	Focus on lifestyle improvement	1

Appendix E. Study 2: Physiotherapist national survey questions

Demographic Information:

1. Gender

   Male, Female, Fill in the blank

2. Which specialization of physiotherapy would you primarily identify with?
   - o Cardiorespiratory
   - o Musculoskeletal
   - o Neurology
   - o Oncology
   - o Paediatrics
   - o Pain Science
   - o Seniors
   - o Sport
   - o Women
   - o Other (please specify)

3. Number of years practicing:

   0-5, 6-10, 11-15, 16-20, 22-25, 26+

4. Do you currently service clients with a spinal cord injury (SCI)?

   Yes, no

If yes to Q4, answer the following:

5. How many clients would you estimate you see with a SCI in a year?

   1-10, 10-20, 30-40, 40+

6. How many times have you prescribed physical activity to clients with SCI?

   1-10, 10-20, 20-30, 30-40, 40+

Physical Activity Knowledge/ Confidence:

7. Would you say there is a difference between physical activity and physiotherapy specific exercise?

   Yes, no

8. If yes, briefly, how would you define the difference between physical activity and physiotherapy specific exercise?

   Open ended (max char short)

9. Which of the following are the current recommended physical activity guidelines for improving fitness in those with SCI?

   a) 20 min, 2x/wk, b) 30 min, 3x/wk, c) 10 min, 5x/wk, d) 20 min, 4x/wk, e) I am unsure

10. Which of the following are the current recommended physical activity guidelines for the general Canadian population ages 18-64 years of age?

    a) 210 min/wk b) 150 min/wk c) 100 min/wk, d) 300 min/wk, e) I am unsure

11. Do you feel your education in physiotherapy (i.e. in university) has prepared you to promote physical activity?

    Yes/ No

12. Do you feel confident to discuss the benefits of physical activity to your clients with SCI?

    0-100 (Not at all confident, Moderately confident, Highly confident as anchors and midway point)

13. Do you feel confident to prescribe physical activity for your clients with SCI?

    0-100 (Not at all confident, Moderately confident, Highly confident as anchors and midway point)

14. Do you feel confident to suggest specific ways your clients with SCI can become active in the community?

0-100 (Not at all confident, Moderately confident, Highly confident as anchors and midway point)

15. Do you refer your clients with SCI to adapted physical activity resources and organizations in your area?

    Yes, No

16. If yes, what are some examples of adapted physical activity resources and organizations that you refer your clients with SCI to?

    Open ended

17. Do you currently use behaviour change strategies to ensure your clients with SCI complete their home exercises (e.g. monitoring, motivational interviewing, goal setting)?

    Yes, No, Unsure of what behaviour change strategies are

18. If yes, which behaviour change strategies do you typically employ?

    Monitoring, motivational interviewing, goal setting, other (open ended)

Barriers to Physical Activity Promotion:

19. Would you identify any of the following as barriers to promoting physical activity to your clients with SCI?

    Lack of time, lack of reimbursement, lack of billing structure, disbelief that it will change client behaviour, lack of resources, lack of interest, feeling it would not be beneficial for the client, lack of knowledge of community referrals, lack of knowledge of how to promote physical activity, lack of confidence to promote physical activity

20. Are there any other barriers that would prevent you from promoting physical activity to your clients with SCI?

    Open-ended

21. Would you identify any of the following as barriers to your clients with SCI participating in physical activity?

    Lack of confidence to participate, lack of time, financial barriers, transportation availability, lack of family support, negative recreation facility staff attitudes, lack of accessible physical activity options, lack of knowledge of how to be physically active, lack of knowledge of resources, physiotherapists not preparing them for an active lifestyle post-discharge?

22. Are there any other barriers that would prevent your clients with SCI in participating in physical activity?

    Open-ended

Feasibility Promotion Strategies:

23. Check which of the following promotion strategies would be feasible in the clinic:

    Brief counseling integrated into regular consultations, separate one-on-one consultations, group sessions, distribution of resources (e.g. brochure)

Physiotherapist's Role:

24. Do you agree the following are part of the physiotherapist's role?

    Discussing the benefits of physical activity with your clients with SCI, prescribing exercise to your clients with SCI, suggesting specific ways to be physically active in the community

    0-100 (Do not agree at all, Moderately agree, Highly agree as anchors and midway point)

Physical Activity Promotion in the Clinic:

25. Do you currently do physical activity (i.e. wheelchair treadmill, arm ergometer, etc. and not including usual PT rehab exercises) with your clients with SCI in the clinic?

    Yes, No

26. Do you promote participation in physical activity outside of the clinic to your clients with SCI?

Yes, No

27. Do you currently have any of the following resources on physical activity in SCI?
    (Check box for each) SCI Physical Activity Guidelines, SCI Get Fit Toolkit
28. Have you referred your clients with SCI to any of the following resources?
    (Check box for each) Active Homes, Get In Motion, Active Living Leaders, SCI Action Canada, Canadian Paralympic Committee, Bridging the Gap
29. Any other resources in addition to those mentioned above?
    Open-ended
30. What types of equipment do you have available in your clinic that could be used for physical activity with your clients with SCI?
    Wheel chair treadmill, arm ergometer, hand cycles, motorized recumbent bikes, seated elliptical, hand gliders, body weight supported treadmill, Functional Electrical Stimulation (FES) cycling, Theraband, wrist weights, medicine balls, boxing equipment, grip assistance gloves/ cuffs, pulleys/ cables, free weights, machine weights with removable seating, Other (Open ended)
31. What types of physical activity can feasibly be done in the clinic?
    Wheeling, biking, arm cycling, boxing, walking, other (Open ended)

Physical Activity Promotion Training:

32. Would you be interested in attending a training session to learn more about physical activity promotion in SCI?
    Yes, No
33. If no/ Why not?
    Open ended
34. If yes/ How would you like to receive training?
    Online workshops, In- person workshop (in clinic), In-person workshop (out of clinic with physiotherapists from other clinics), Other (please specify)
35. Who would be appropriate people to deliver the training (can check more than one)? Physiotherapist, Researcher, Representative with SCI, Canadian Paralympic Committee Representative

Physical Activity Promotion Toolkit:

36. Would you use a toolkit outlining how to promote physical activity to your clients with SCI?
    Yes, No
37. If no/ Why not?
38. Which of the following would you be most likely to use to promote physical activity to your clients with SCI:
    Having a list of options for implementing physical activity promotion within the clinic
    Having a single evidenced based recommendation for implementing physical activity promotion as decided by a physiotherapist expert panel for implementing physical activity promotion
    Both approaches are equally as likely to be used
39. Which of the following would be most useful to your learning how to promote physical activity to your clients with SCI:
    A toolkit outlining behaviour change strategies, clinic feasible exercises, benefits and barriers to physical activity
    Online booklet with behaviour change strategies, clinic feasible exercises, benefits and barriers to physical activity
    Physical activity prescription pad

Separate pamphlets with behaviour change strategies, clinic feasible exercises, benefits and barriers to physical activity

If no to Q4, answer the following:

1. How many times have you prescribed physical activity to your clients?
   1-10, 10-20, 20-30, 30-40, 40+

Physical Activity Knowledge/ Confidence:

2. Would you say there is a difference between physical activity and physiotherapy specific exercise?
   Yes, no
3. If yes, briefly, how would you define the difference between physical activity and physiotherapy specific exercise?
   Open ended (max char short)
4. Which of the following are the current recommended physical activity guidelines for the general Canadian population ages 18-64 years of age?
   a) 210 min/wk b) 150 min/wk c) 100 min/wk, d) 300 min/wk, e) I am unsure
5. Do you feel your education in physiotherapy (i.e. in university) has prepared you to promote physical activity?
   Yes/ No
6. Do you feel confident to discuss the benefits of physical activity to your clients?
   0-100 (Not at all confident, Moderately confident, Highly confident as anchors and midway point)
7. Do you feel confident to prescribe physical activity for your clients?
   0-100 (Not at all confident, Moderately confident, Highly confident as anchors and midway point)
8. Do you feel confident to suggest specific ways your clients can become active in the community?
   0-100 (Not at all confident, Moderately confident, Highly confident as anchors and midway point)
9. Do you refer your clients to physical activity resources and organizations in your area?
   Yes, No
10. If yes, what are some examples of physical activity resources and organizations that you refer your clients to?
    Open ended
11. Do you currently use behaviour change strategies to ensure your clients complete their home exercises (e.g. monitoring, motivational interviewing, goal setting)?
    Yes, No, Unsure of what behaviour change strategies are
12. If yes, which behaviour change strategies do you typically employ?
    Monitoring, motivational interviewing, goal setting, other (open ended)

Barriers to Physical Activity Promotion:

13. Would you identify any of the following as barriers to promoting physical activity to your clients?
    Lack of time, lack of reimbursement, lack of billing structure, disbelief that it will change client behaviour, lack of resources, lack of interest, feeling it would not be beneficial for the client, lack of knowledge of community referrals, lack of knowledge of how to promote physical activity, lack of confidence to promote physical activity
14. Are there any other barriers that would prevent you from promoting physical activity to your clients?
    Open-ended

15. Would you identify any of the following as barriers to your clients participating in physical activity?
    Lack of confidence to participate, lack of time, financial barriers, transportation availability, lack of family support, negative recreation facility staff attitudes, lack of physical activity options, lack of knowledge of how to be physically active, lack of knowledge of resources
16. Are there any other barriers that prevent your clients in participating in physical activity?
    Open ended

Feasibility Promotion Strategies:

17. Check which of the following promotion strategies would be feasible in the clinic:
    Brief counseling integrated into regular consultations, separate one-on-one consultations, group sessions, distribution of resources (e.g. brochure)

Physiotherapist's Role:

1. Do you agree the following are part of the physiotherapist's role?
   (Rate each of the following) Discussing the benefits of physical activity with your clients, prescribing exercise to your clients, suggesting specific ways to be physically active in the community
   0-100 (Do not agree at all, Moderately agree, Highly agree as anchors and midway point)

Physical Activity Promotion in the Clinic:

18. Do you currently do physical activity (i.e. running, cycling, etc. and not including usual PT rehab exercises) with your clients in the clinic?
    Yes, No
19. Do you promote participation in physical activity outside of the clinic to your clients?
    Yes, No
20. Do you currently have the Canadian Physical Activity Guidelines available for distribution in the clinic?
    Yes, No
21. Any other physical activity resources available for distribution in the clinic?
    Open ended
22. What types of equipment do you have available in your clinic that could be used for physical activity with your clients?
    Treadmill, bicycle, elliptical, exercise balls, Theraband, wrist weights, medicine balls, boxing equipment, grip assistance gloves/ cuffs, pulleys/ cables, free weights, machine weights, Other (Open ended)
23. What types of physical activity can feasibly be done in the clinic?
    Walking, running, biking, arm cycling, boxing, other (Open ended)

Physical Activity Promotion Training:

24. Would you be interested in attending a training session to learn more about physical activity promotion for your clients?
    Yes, No
25. If no/ Why not?
    Open ended
26. If yes/ How would you like to receive training?
    Online workshops, In- person workshop (in clinic), In-person workshop (out of clinic with physiotherapists from other clinics), Other (please specify)
27. Who would be appropriate people to deliver the training (can check more than one)?

Physiotherapist, researcher, physician, other (please specify)

Physical Activity Promotion Toolkit:

28. Would you use a toolkit outlining how to promote physical activity to your clients?
    Yes, No
29. If no/ Why not?
30. Which of the following would be most useful to your learning how to promote physical activity to your clients:
    A toolkit outlining behaviour change strategies, clinic feasible exercises, benefits and barriers to physical activity
    Online booklet with behaviour change strategies, clinic feasible exercises, benefits and barriers to physical activity
    Physical activity prescription pad
    Pamphlets with behaviour change strategies, clinic feasible exercises, benefits and barriers to physical activity
31. Which of the following would be most useful to your learning how to promote physical activity:
    Having a list of options for implementing physical activity promotion within the clinic
    Having a single evidenced based recommendation as decided by the general population for implementing physical activity promotion
    Both approaches are equally as likely to be used

Appendix F. Study 2: Physiotherapist national survey response frequencies

	SCI (n=35)		General (n=204)	
	Frequency	%	Frequency	%
Canadian PA Guidelines				
Correct	23	65.7	113	55.4
Incorrect	12	34.3	90	44.6
My formal training as a physiotherapist prepared me to promote physical activity to my clients?				
Strongly Disagree			6	2.9
Disagree	1	2.9	11	5.4
Neutral	6	17.1	29	14.2
Agree	20	57.1	115	56.4
Strongly Agree	8	22.9	43	21.1
Would you say there is a difference between physical activity and physiotherapy specific exercise?				
Yes	30	85.7	192	94.1
No	5	14.3	12	5.9
How many times have you prescribed physical activity to your clients within the past year?				
1-10	24	68.6	9	4.4
10-20	5	14.3	16	7.8
20-30	1	2.9	14	6.9
30-40	3	8.6	21	10.3
40+	2	5.7	144	70.6
Confidence to…				
Discuss the benefits of physical activity with your clients? (Scale of 0-100%)		90.7		87.1

Prescribe physical activity to your clients? (Scale of 0-100%)		72.5		85.1
Suggest specific resources, programs, activities, etc. to your clients? (Scale of 0-100%)		63.8		78.8
Do you refer your clients to physical activity organizations or programs in your area?				
Yes	24	68.6	156	76.5
No	11	31.4	45	22.1
Do you currently use behaviour change strategies to ensure your clients complete their current rehabilitative exercises at home (e.g. self-monitoring, motivational interviewing, goal setting)?				
Yes	19	54.3	141	69.1
No	16	45.7	48	23.5
Which behaviour change strategies do you typically employ?				
Action planning	11	31.4	77	37.7
Implementation intentions	3	8.6	28	13.7
Self- monitoring	14	40.0	94	46.1
Reinforcing progress	10	28.6	91	44.6
Motivational interviewing	3	8.6	49	24.0
Goal setting	18	51.4	129	63.2
Other	3	8.6	10	4.9
Are any of the following barriers, for you as a physiotherapist, to promoting physical activity to your clients?				
Lack of confidence	12	34.3	11	5.4
Lack of time	16	45.7	89	43.6
Lack of financial compensation	5	14.3	24	11.8

Lack of resources	21	60.0	65	31.9
Lack of support from employers	2	5.7	22	10.8
Lack of accessible physical activity options	26	74.3	73	35.8
Lack of knowledge of how to to prescribe physical activity	7	20.0	19	9.3
Other	15	44.1	61	30.5
Physiotherapist's role: Discussing the benefits of physical activity with your clients				
Strongly Disagree	1	2.9	7	3.5
Disagree	0	0.0	0	0
Neutral	0	0	2	1.0
Agree	6	17.6	45	22.4
Strongly Agree	27	79.4	147	73.1
Prescribing exercise to your clients				
Strongly Disagree	1	2.9	5	2.5
Disagree	0	0	0	0
Neutral	0	0	4	2.0
Agree	4	11.8	32	15.8
Strongly Agree	29	85.3	161	79.7
Providing ongoing support to help your clients become physically active				
Strongly Disagree	1	2.9	3	1.5
Disagree	0	0.0	3	1.5
Neutral	4	11.8	15	7.5
Agree	9	26.5	86	43.0
Strongly Agree	20	58.8	93	46.5
Do you currently have your clients partake in physical activity (i.e. wheelchair treadmill, arm ergometer, etc. and not including usual PT rehab exercises) in the clinic?				

Yes	25	75.8	126	62.7
No	8	24.2	75	37.3
Do you encourage participation in physical activity outside of the clinic to your clients?				
Yes	29	85.3	197	98.0
No	5	14.7	4	2.0
Do you prescribe physical activity outside of the clinic to your clients?				
Yes	24	70.6	171	85.5
No	10	29.4	29	14.5
Do you currently have any of the following resources on physical activity?				
SCI Physical Activity Guidelines	15	42.9		
SCI Get Fit Toolkit	5	14.3		
Canadian Physical Activity Guidelines			48	23.8
Other			124	60.8
Have you referred your clients to any of the following resources? (Can check more than one)				
Active Homes	0			
Get In Motion	4	11.4		
Active Living Leaders	1	2.9		
SCI Action Canada	11	31.4		
Canadian Paralympic Committee	9	25.7		
Bridging the Gap	7	20.0		
Other	4	11.4		
What types of equipment do you have available in your clinic that could be used for physical activity with your clients?				
Wheelchair treadmill	3	8.6		
Arm ergometer	22	62.9		

Hand cycles	5	14.3		
Motorized recumbent bikes	12	34.3		
Seated elliptical	6	17.1		
Hand gliders	4	11.4		
Machine weights with removable seating	7	20.0		
Body weight supported treadmill	12	34.3		
Functional Electrical Stimulation (FES) Cycling	7	20.0		
Theraband	32	91.4	184	90.2
Wrist Weights	29	82.9	127	62.3
Medicine balls	24	68.6	99	48.5
Grip assistance gloves/ cuffs	16	45.7	29	14.2
Pulleys/ cables	20	57.1	122	59.8
Boxing equipment	7	20.0	8	3.9
Free weights	28	80.0	160	78.4
Treadmill			137	67.2
Bicycle			149	73.0
Elliptical			43	21.1
Exercise Balls			163	79.9
Machine Weights			71	34.8
Other	6	17.1	67	32.8
What types of physical activity can feasibly be done in your clinic?				
Wheeling	16	45.7		
Biking	15	42.9	166	81.4
Arm Cycling	25	71.4	81	39.7
Boxing	10	28.6	11	5.4
Walking	27	77.1	166	81.4
Other	11	31.4	74	36.3

Which of the following physical activity promotion strategies would be feasible in the clinic:				
Brief counseling integrated into regular consultations	24	68.6	169	82.8
Separate one-on-one consultations	23	65.7	77	37.7
Group information/discussion sessions	15	42.9	84	41.2
Distribution of resources (e.g. brochure)	29	82.9	165	80.9
Other	1	2.9	14	6.9
Would you be interested in attending a training session to learn more about physical activity promotion for persons?				
Yes	28	82.4	154	77.4
No	6	17.6	45	22.6
If yes, how would you best prefer to receive training?				
Online workshops	17	48.6	132	64.7
In- person workshop (in clinic)	12	34.3	45	22.1
In-person workshop (out of clinic with physiotherapists from other clinics)	15	42.9	55	27.0
Other	1	2.9		
Who would be appropriate people to deliver the training?				
Physiotherapist	34	97.1	193	94.6
Researcher	19	54.3	87	42.6
Respresentative with SCI	23	65.7		
Canadian Paralympic Committee Representative	15	42.9		
Kinesiologist	14	40.0	124	60.8
Physiatrist	13	37.1	65	31.9
Other	2	5.7	16	7.8

Would you use a toolkit designed specifically for physiotherapists outlining how to promote physical activity to your clients?				
Yes	34	97.1	183	89.7
No	0	0	14	6.9
Which of the following would you be most likely to use to promote physical activity to your clients:				
Having a list of options for implementing physical activity promotion within the clinic	6	17.6	40	20.5
Having a single evidenced based recommendation for implementing physical activity promotion as decided by a physiotherap	2	5.9	23	11.8
Both approaches are equally as likely to be used	26	76.5	132	67.7
Which of the following would be useful to your learning how to promote physical activity to your clients with SCI:				
A toolkit outlining behaviour change strategies	22	62.9	154	75.5
Clinic feasible exercises	27	77.1	99	48.5
Benefits and barriers to physical activity	19	54.3	114	55.9
Online booklet with behaviour change strategies	20	57.1	126	61.8
Physical activity prescription pad	13	37.1	109	53.4
	12	34.3	109	53.4
Separate pamphlets with behaviour change strategies				
Other:	3	8.6	11	5.4
Of these, which would be the **Most Useful** to your learning how to promote physical activity to your clients with SCI:				
A toolkit outlining behaviour change strategies	10	29.4	62	31.3
Clinic feasible exercises	13	38.2	41	20.7
Benefits and barriers to physical activity	3	8.8	26	13.1
Online booklet with behaviour change strategies	5	14.7	26	13.1

Physical activity prescription pad	2	5.9	22	11.1
Separate pamphlets with behaviour change strategies	1	2.9	15	7.6

Appendix G. Study 2: Modified Theoretical Domains Framework questionnaire

Response options for all questions

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Rate your agreement/ disagreement with the following statements:

Knowledge

1) I know how to promote physical activity to clients with SCI
2) The potential objectives of physical activity promotion to clients with SCI are clear to me
3) With regard to physical activity promotion to clients with SCI, I know specifically what role a physiotherapist can take on
4) When promoting physical activity to clients with SCI I know exactly what steps I would take

Skills

5) I have been trained in how to promote physical activity to clients with SCI
6) I have the skills to promote physical activity to clients with SCI

Beliefs About Capabilities

7) I am confident that I can promote physical activity to clients with SCI
8) I am confident that I can promote physical activity to clients with SCI when other professionals with whom I work with do not do this
9) I am confident that I can promote physical activity to clients with SCI even when there is little time
10) I am confident that I can promote physical activity to clients with SCI even when clients are not motivated

Innovation/ Environmental Context and Resources

In your current situation with your current resources…

11) There is time to effectively promote physical activity to clients with SCI
12) I have the resources to effectively promote physical activity to clients with SCI

Intentions

Assuming you have clients with an SCI or were to have clients with an SCI in the next three months, rate your agreement/ disagreement with the following statements:

13) I intend to promote physical activity to my clients in the next three months
14) I will promote physical activity in the next three months
15) My intention to promote physical activity in the next three months is strong

Appendix H. Study 2: Modified APEASE questionnaire

All questionnaires will use the following response options:

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

1) The ProacTive SCI Toolkit is **affordable** to implement:

‘**Practicable’** Questions

2) The ProacTive SCI Toolkit requires little time to implement
3) It is possible to tailor PA promotion to the physiotherapists’ needs using the ProacTive SCI Toolkit
4) The ProacTive SCI toolkit is suitable for daily practice
5) The ProacTive SCI toolkit is simple to deliver

6) The ProacTive SCI Toolkit will be **effective** in changing physical activity for clients with spinal cord injury

7) The ProacTive SCI Toolkit is **cost-effective** to implement:

8) The ProacTive SCI Toolkit would be **acceptable** to implement within my practice’s structure

9) There are no **side-effects/safety** concerns associated with implementing the ProacTive SCI Toolkit

10) Physiotherapists from different settings (e.g. clinics, in-patient, out-patient, private practice) would have **equal** opportunity to benefit from the ProacTive Toolkit:

Appendix I. Study 2: Expert panel recommendations checklist

Discussion Topic #1: Physical Activity Prescription/ Clinic Feasible Exercise	
****Clinic feasible exercise should not be the focus, instead focus on at-home and community exercise**	
Page Ref.	**Recommendation Reference Code) Recommendation**
Education	
34	1) Educate clients on how to do PA at home
e.g.24, 11, 28	2) Educate clients on how to do PA in the community
3 (mentioned 10)	3) Highlight the link between rehab exercises and PA
23, 36	4) Address the barrier of cost
23	5) Address the barrier of transportation
	6) Include practical, real life examples of programs
Link	
e.g.14, 24,25, 35, 36, 21, 26, 27, 28, 37	7) Link to other resources
23, 28	8) Link to other professionals
e.g.24, 25, 21, 28	9) Link to other programs and facilities
24	10) Refer to able- bodied resources
24, 28	11) Refer to other programs and professionals experienced in working with SCI
28	12) Incorporate Kinesiologists
23, 27, 28	13) Emphasize the importance of word of mouth referrals
15, 27	14) Encourage group exercise
14, 24, 25, 28	15) Make connections with the community
Tailor to the Individual	
7, 31, 33, 35, 37 (mentioned 16,) 32	16) Emphasize that programs need to be tailored
7, 15, 33, 34	17) Graded Tasks: 3 Phase spectrum to accomplishing goals based on the client's readiness
33	a. Just get moving, focusing on the little things e.g. wheeling to work, basic exercises at home
34	b. Start trying organized exercise/ recreation, independent activity
35, 36	c. Exercising regularly and meeting the guidelines through organized sport
31 , 32	18) Workouts need to be interesting to the client
34, 40	19) Suggest doing activity while watching TV if just starting
Philosophy	
37	20) "Work what works"
	21) Frame PA in SCI as not that different from general PA
5, 37	22) Help address fear of working with SCI/ barrier of PTs thinking they can't help

2, 37 (mentioned 4,) 5	23) Safety needs to come first
7	24) Make it the culture that PA should be part of everyday life
15	25) Emphasize flexibility: Adapt to the person
7, 31, 37	26) Don't be afraid to push the clients who are ready and willing
5, 37	27) Be mindful of arms/ shoulders overuse
2, 31, 23(28 on pdf but not sure if present), 32	28) Need to tailor PA program to level of motivation
Discussion Topic #2: Linking- Individual/ Community Level	
	29) Compile an online, comprehensive "one stop shop" searchable database of facilities/ programs, with map, various activity levels, able-bodied/ inclusive options
24	30) Address the issue of linking to resources in small communities
Peer to Peer Connections	
27	31) Encourage linking with a peer with similar injury and interests
27	32) Need to consider context and readiness of the patient when referring to a peer
27	33) Could be as simple as asking the question: "Would you be interested in connecting with a peer?"
Events	
e.g. 27, 36	34) Recommend provincial SCI organizations (e.g. SCI Ontario) to pair with a peer
36	35) Encourage going to SCI events
Other links	
28	36) Provide examples of professionals/ organizations to link with: Rehab support workers, personal support workers, schools, champions, family members/ caregivers (help maintain the continuum of care), OKA, Physiopedia, hospital reps, college of physiotherapists, physiatrists
34, (37 on pdf but not sure if present)	37) Other indoor solutions e.g. mall/ arena rolling
Philosophies	
24, 25	38) Linking to a resource needs to be quick for the PT
Discussion Topic #3: Linking Organizational Level	
Connect with local programs	
28, 23	39) Call them/ establish a relationship: can be symbiotic
28	40) Try and connect face to face if possible (e.g. in- person, Skype)
23, 28	41) Incorporate family
17	42) Have follow-up after discharge to ensure transition into community
28	43) Advocate for making facility accessible (e.g. making space for chairs, purchasing grip assistance gloves)
Other	
21	44) Have educational videos

Discussion Topic #4: Behaviour Change Techniques	
**Motivational Interviewing recently taught in PT school, but be aware may not have internalized it	
Motivational phase (still thinking about whether they want to become an exerciser)	
10, 31	45) Increase salience of PA participation: Link goals to everyday life situations, function, personal life; place less emphasis on disease risk. Ask the CLIENT what is important to them
31	46) Explain purpose: why does X exercise need to be done and what does it accomplish?
Volitional phase (Wants to exercise but needs help implementing and maintaining)	
17, 18	47) Follow- Up/ Monitoring
13, 19	48) Goal setting: SMART goals
14	49) Coping planning: Identify barriers (esp. environmental) and problem solving
12, 14, 16, 20, 31, 38	50) Include practical, real life examples
Discussion #5: Format	
Resource formats:	
	51) Online (with print options), print copies
Website:	
3, 4, 22, 30	52) Checklist Overview: all sections/ components of topics on PA for people with SCI
1	53) Ensure name is searchable
26	54) Link toolkit with SCI Get Fit Toolkit
3 (see item 52)	55) Sections layered: 1) Brief take home 2) One-page summary 3) Full summary
	Section examples:
8	56) PA basics
9, 7	57) Guidelines
37	58) PA prescription
	59) Searchable database of resources (see discussion #2)
38, 39, 40	60) Sample programs
41	61) How to adapt common exercise equipment
29	62) Discussion page to share exercises
	63) Interactive webpage to share current information
21, 37, 10, 11?, , 15, 20 , 38, 39, 40	64) Pictures of people exercising with different injury levels

Appendix J. Study 3: Leisure Time Physical Activity Questionnaire for People with Spinal Cord Injury

Leisure Time Physical Activity Questionnaire for People with Spinal Cord Injury

(LTPAQ-SCI)

INSTRUCTIONS: I am going to ask you about the time you spent engaging in mild, moderate, and heavy intensity LTPA in the last 7 days. Leisure Time Physical Activity (LTPA) is physical activity that you choose to do during your free time, such as exercising, playing sports, gardening, and taking the dog for a walk (necessary physical activities such as physiotherapy, grocery shopping, pushing/wheeling for transportation are not considered LTPA). Please refer to the intensity chart (next page) for descriptions of what mild, moderate and heavy intensity LTPA feel like.

1. Mild intensity LTPA requires very light physical effort; mild intensity activities make you feel like you are working a little bit, but you can keep doing them for a long time without getting tired…

   During the last 7 days, on how many days did you do mild intensity LTPA? _______

   On those days, how many minutes did you usually spend doing mild intensity LTPA? ______

2. Moderate intensity LTPA requires some physical effort; moderate intensity activities make you feel like you are working somewhat hard, but you can keep doing them for a while without getting tired…

   During the last 7 days, on how many days did you do moderate intensity LTPA? _______

   On those days, how many minutes did you usually spend doing moderate intensity LTPA? ______

3. Heavy intensity LTPA requires a lot of physical effort. Heavy intensity activities make you feel like you are working really hard, almost at your maximum. You cannot do these activities for very long without getting tired. These activities may be exhausting.

   During the last 7 days, on how many days did you do heavy intensity LTPA? _______

   On those days, how many minutes did you usually spend doing heavy intensity LTPA? ______

!

	Nothing at all	Mild	Moderate	Heavy
How hard are you working?				
	· Includes activities that even when you are doing them, you do not feel like you are working at all.	· Includes physical activities that require you to do very light work. You should feel like you are working a little bit but overall you shouldn't find yourself working too hard	· Includes physical activities that require some physical effort. You should feel like you are working somewhat hard but you should feel like you can keep going for a long time.	· Includes physical activities that require a lot of physical effort. You should feel like you are working really hard (almost at your maximum) and can only do the activity for a short time before getting tired. These activities can be exhausting
How does your body feel?				
Breathing & Heart rate	Everything is normal	· Stays normal or is only a little bit harder and/or faster than normal	· Noticeably harder and faster than normal but NOT extremely hard or fast	· Fairly hard and much faster than normal.
Muscles		· Feel loose, warmed-up and relaxed. Feel normal temperature or a little bit warmer and not tired at all	· Feel pumped and worked. Feel warmer than normal and starting to get tired after awhile.	· Burn and feel tight and tense. Feel a lot warmer than normal and feel tired.
Skin		· Normal temperature or is only a little bit warmer and not sweaty	· A little bit warmer than normal and might be a little sweaty	· Much warmer than normal and might be sweaty
Mind		· You might feel very alert. Has no effect on concentration	· Require some concentration to complete	· Requires a lot of concentration (almost full) to complete

!

Appendix K. Study 3: HAPA questionnaire

Predictors of Physical Activity
REGULAR PARTICIPATION in LTPA

Outcome Expectancies

To what extent do you think that participating in moderate to heavy LTPA for 20 minutes, at least 2 days per week, over the next month would be:

	☐	☐	☐	☐	☐	☐	☐	
Extremely Unenjoyable	1	2	3	4	5	6	7	Extremely Enjoyable
Extremely Harmful	1	2	3	4	5	6	7	Extremely Beneficial
Extremely Unpleasant	1	2	3	4	5	6	7	Extremely Pleasant
Extremely Bad	1	2	3	4	5	6	7	Extremely Good
Extremely Stressful	1	2	3	4	5	6	7	Extremely Relaxing
Extremely Worthless	1	2	3	4	5	6	7	Extremely Valuable

Intentions

To what extent is the following statement true for you?: I will try to do 20 minutes of moderate to heavy LTPA at least 2 days per week over the next month.

	☐	☐	☐	☐	☐	☐	☐	
Definitely False	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Definitely True**

To what extent is the following statement likely?: I intend to do 20 minutes of moderate to heavy LTPA at least 2 days per week over the next month.

	☐	☐	☐	☐	☐	☐	☐	
Extremely Unlikely	1	2	3	4	5	6	7	Extremely Likely

The following scale will be used for the next section of questions:

Now I am going to ask you some questions about your confidence to participate in LTPA under various conditions. For these questions, I'd like you to rate your confidence on a scale of 1-7 where:

1 = not at all confident   4 = moderately confident   7 = completely confident

Aerobic Exercise Task Self-Efficacy
"I am going to ask you about AEROBIC activity. This includes activities that typically increase heart rate and breathing such as wheeling, swimming, and basketball."

If you had all of the resources you needed, such as specialized equipment or an assistant, how confident are you that you could physically do the following amounts of MODERATE intensity AEROBIC activity without stopping:

10 min
20 min
30 min
45 min
60 min

If you had all of the resources you needed, such as specialized equipment or an assistant, how confident are you that you could physically do the following amounts of HEAVY intensity AEROBIC activity without stopping:

10 min
20 min
30 min
45 min
60 min

Strength Exercise Task Self-Efficacy

"I am going to ask you about STRENGTH activity. This includes activities that typically muscular strength and function such as lifting weights, using pulleys or resistance bands."

If you had all of the resources you needed, such as specialized equipment or an assistant, how confident are you that you could physically do the following amounts of MODERATE intensity STRENGTH activity without stopping:

10 min
20 min
30 min
45 min
60 min

If you had all of the resources you needed, such as specialized equipment or an assistant, how confident are you that you could physically do the following amounts of HEAVY intensity STRENGTH activity without stopping:

10 min
20 min
30 min
45 min
60 min

Barrier/ Maintenance Self-Efficacy

Assuming you were very motivated, how confident are you that you will participate in moderate to heavy LTPA for 20 minutes, at least 2 days per week over the next month even if:

1) You feel tired or fatigued
2) You get busy or have limited time
3) You have transportation problems
4) You have pain or soreness
5) The weather is very bad
6) You do not have someone to help you exercise

Recovery Self-Efficacy

1) Over the next month, how confident are you that you can:
2) **Anticipate problems that might interfere withyour LTPA schedule.**
3) **Develop solutions to cope with potential barriers that can interfere with your LTPA**
4) **Resume regular LTPA when it's interrupted and you miss LTPA for a few days.**
5) **Resume regular LTPA when it's interrupted and you miss LTPA for a few weeks.**
6) **Identify key factors that trigger lapses in your LTPA program.**
7) **Accept lapses in your LTPA program as normal.**
8) **View lapses in your LTPA program as challenges to overcome rather than failures.**
9) Goal Setting Self-Efficacy
10) **Set realistic goals for increasing your exercise.**
11) **Develop plans to reach your exercise goals.**

Scheduling Self-Efficacy

Assuming that you were very motivated, over the next month, how confident are you that you can fit 20 min of moderate-heavy LTPA into your weekly schedule:

a. Once per week
b. Twice per week
c. Three times per week
d. More than three times per week

Planning

(a) I have made a detailed plan regarding when to participate in LTPA

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

(b) I have made a detailed plan regarding where to participate in LTPA

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

(c) I have made a detailed plan regarding what types of LTPA to do

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

(d) I have made a detailed plan regarding <u>how often</u> to participate in LTPA

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

Monitoring (Action Control)

(b) I constantly monitor whether I engage in LTPA often enough

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

(f) I am careful to ensure that I am active for at least 30 minutes at a moderate to heavy intensity, each time I engage in LTPA

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

(g) My physical activity program is often on my mind

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

(h) I am constantly aware of my physical activity program

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

(i) I really try to engage in LTPA regularly

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

(j) I try my best to meet my own standards for being physically active

Definitely False	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Definitely True

Risk Perceptions

How serious of a threat do you perceive exercise to be in triggering an episode of autonomic dysreflexia?

Not al all Severe	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Very Severe

How serious of a threat do you perceive exercise to be in causing you injury or harm?

Not al all Severe	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	Very Severe

Social Support

Social Support (Emotional)

1. During the past two months, my family or friends:
2. Did physical activity with me
3. Gave me encouragement to stick with my physical activity program
4. Offered to do physical activity with me

Social Support (Practical)

1. Gave me helpful reminders to do physical activity
2. Provided transportation to get to physical activity
3. Helped me do physical activity
4. Helped me plan my physical activity
5. Monitored my physical activity

Physical Resources/ Barriers

This scale will be used for the following sections:

Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

1. Facilities are available to help me to do physical activity
2. Programs are available to help me to do physical activity
3. There is NO WHERE to do physical activity near me
4. Equipment is available for me to do physical activity
5. Being physically active is expensive
6. I have a means of transportation to enable me to do physical activity

Psychological Resources/ Barriers

1. I know where to go to do strength exercise
2. I know where to go to do aerobic exercise
3. I know how to do 3 sets of 8-10 repetitions of strength exercise for each major functioning muscle group
4. I know how to do at least 20 minutes of moderate to vigorous intensity aerobic exercise
5. I know the types of equipment I can use to do strength exercises
6. I know the types of equipment I can use to do aerobic exercise

Appendix L: Study 3: Behaviour change technique coding manual and support for inclusion of each behaviour change technique

Behaviour Change Techniques	Reference
1.1 Goal setting (behavior)	HAPA-action control
1.2 Problem solving	HAPA-action control, coping planning, recovery self-efficacy
1.3 Goal setting (outcome)	HAPA-action control
1.4 Action planning	HAPA-action planning
1.5 Review behavior goal(s)	HAPA-action control
1.6 Discrepancy between current behavior and goal	HAPA-action control
1.8 Behavioral contract	Ma and Martin Ginis, 2018
1.9 Commitment	Ma and Martin Ginis, 2018
2.2 Feedback on behavior	HAPA-action control
2.3 Self-monitoring of behavior	HAPA-action control
2.4 Self-monitoring of outcome(s) of behavior	HAPA-action control
2.6 Biofeedback	Expert panel recommendation
2.7 Feedback on outcome(s) of behavior	HAPA-action control
3.1 Social support (unspecified)	HAPA-barriers and resources
3.2 Social support (practical)	HAPA-barriers and resources
3.3 Social support (emotional)	HAPA-barriers and resources
4.1 Instruction on how to perform a behavior	Williams et al., 2017
5.1 Information about health consequences	HAPA-outcome expectancies, risk perceptions
5.3 Information about social and environmental consequences	HAPA-outcome expectancies, risk perceptions
5.6 Information about emotional consequences	HAPA-outcome expectancies, risk perceptions
6.1 Demonstration of the behavior	Ma and Martin Ginis, 2018
7.1 Prompts/cues	Expert panel recommendation
8.1 Behavioral practice/ rehearsal	HAPA-task self-efficacy
8.7 Graded tasks	HAPA-task self-efficacy
10.2 Material reward (behavior)	Ma and Martin Ginis, 2018
10.4 Social reward	Ma and Martin Ginis, 2018
10.9 Self-reward	Ma and Martin Ginis, 2018
12.1 Restructuring the physical environment	Latimer et al., 2013
12.2 Restructuring the social environment	Expert panel recommendation
12.4 Distraction	Stork et al., (in preparation)
12.5 Adding objects to the environment	Latimer et al., 2013
13.1 Identification of self as role model	Ma and Martin Ginis, 2018
13.2 Framing/reframing	Expert panel recommendation
15.1 Verbal persuasion about capability	HAPA-task self-efficacy
15.3 Focus on past success	HAPA-task self-efficacy
16.3 Vicarious consequences	HAPA-task self-efficacy

ProACTIVE Specific Coding Instructions

If providing any safety information: Code as Instructions on How to Perform the Behaviour AND Information about Health Consequences

Social support practical (don't code for other cases) other than for information related to referral/resources

Social support emotional: encouragement, praise

Social support unspecified: Refer to friends, colleagues, family for general support

Identification of self as role model: also include others as role models

Tailoring: Just look for exemplary situations

Planning to facilitate behaviour e.g. planning what gyms you'll use: Problem solving

Add Participant BCT: if BCT was initiated by participant

Coding same BCT multiple times: only recode when a new concept and code at the beginning of a concept

Only code BCT is actually did it not just discussed it

Coding scheme for (highlight in comment box):

- Additional BCT (green):
- Not a BCT (yellow):
- Unsure (blue):
- Participant BCT (purple):

Exercise programs: code as providign instructions on how to perform the behaviour, behavioural practice, and demonstration of the behaviour for session 1, all other session code as instructions on how to perform the behaviour unless explicitly stated

Break up social support practical→ referrals to people, places, programs etc.

Break up instructions on how to perform the behaviour→ intensity, technique, exercise types, frequency, time

Problem solving: only include if both identification of barrier and solution

Review goal: code when goal setting was already established and are revisiting the goal

Behavioural practice/rehearsal: Advise to try a gym code as Behavioral practice/ rehearsal

Appendix M. Study 3: Intervention group physical activity over time

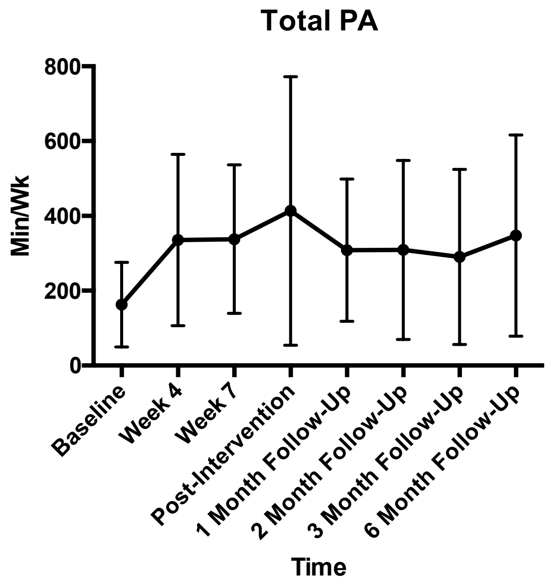

Figure 1. Total physical activity means±SD during the intervention and at 1, 2, 3, and 6 months follow-up in the intervention group

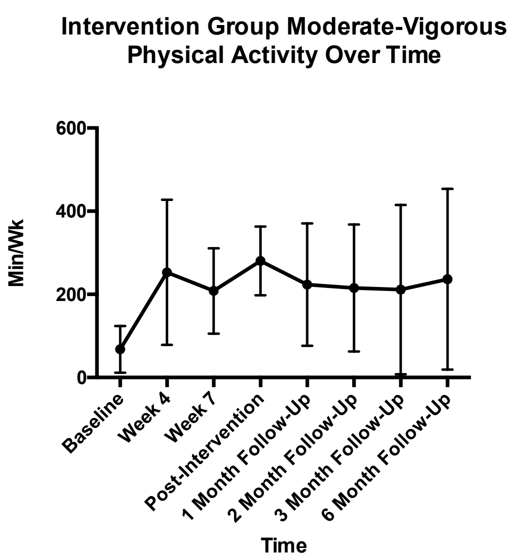

Figure 2. Moderate-vigorous physical activity means±SD during the intervention and at 1, 2, 3, and 6 months follow-up in the intervention group