SCIRE
SPINAL CORD INJURY RESEARCH EVIDENCE
Professional

Physical Activity Following Spinal Cord Injury: Participation

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Key Points

Physical Activity Measurement

Physical activity has been measured in smaller and larger samples of people with SCI using both self-report measures and wearable devices.

There is Level 5 evidence from 19 studies that physical activity levels are low in people with SCI.

Correlates of Physical Activity Participation and Barriers/Facilitators to Physical Activity

There is level 5 evidence from 27 studies of correlates of physical activity participation that physical activity is related to intrapersonal, interpersonal, institutional, community and policy-level factors among adults with SCI.

There is level 5 evidence from 13 studies that intrapersonal, interpersonal, institutional, community and policy-level factors can create both barriers and facilitators to physical activity participation for people with SCI.

Interventions to Promote Physical Activity

There is level 1a evidence from three RCTs, as well as support from three lower quality RCTs and four additional studies, that behavioural interventions are effective for increasing physical activity-related psychosocial variables among persons with SCI.

There is level 1a evidence from four RCTs, as well as support from four lower quality RCTs, one prospective controlled trial, and five additional studies, that behavioural interventions are effective for increasing physical activity behaviour among persons with SCI.

There is level 1b evidence from one RCT that informational interventions are effective for increasing physical activity-related psychosocial variables among persons with SCI.

Future research should seek to fully employ behavioural theory throughout intervention design and evaluation, conduct a process evaluation to consider additional intervention components that influence effectiveness (e.g., dose, tailoring, delivery mode, provider), and design interventions that foster and evaluate long-term changes in leisure-time physical activity psychosocial variables and participation.

Tools to Support Physical Activity Dissemination and Implementation

There is level 1b evidence from one RCT that a knowledge translation tool supported by a behavioural intervention can improve physical activity behaviour among people with SCI.

There is level 4 evidence from one pre-post study that demonstration, practice, and feedback are important behaviour change techniques to include when training interventionists to deliver strategies to increase physical activity levels.

There is level 4 evidence from one pre-post study that intervention dose, the use of both informational and behavioural strategies, and clients' perceptions of service credibility are important physical activity session implementation factors.

Addressing physical activity behaviour for people with SCI needs to extend beyond passive education.

Integrating behaviour change techniques at both the participant (i.e., individual with SCI) and health professional levels are needed to support increasing physical activity behaviour in non-research settings.

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1 Executive Summary

The fitness, health and subjective well-being benefits of routine physical activity participation for adults with spinal cord injury (SCI) are well-documented. However, physical activity participation rates are low among persons with SCI, stemming from the multi-level barriers that they face. Interventions are needed to address these barriers and optimize physical activity participation. Informational and behavioural interventions have demonstrated that physical activity-related psychosocial variables and participation among persons with SCI are amenable to change. In recent years, there has been an increased focus on translating physical activity promotion efforts into community and clinical settings with dissemination and implementation efforts.

This module begins with definitions of physical activity-related terms used. We then review studies that have measured the amount of physical activity performed by adults with SCI. Persons with SCI engage in low average daily and weekly amounts of physical activity (i.e., approximately 50% of the SCI population does no physical activity whatsoever); however, there is tremendous variability in reported participation rates. The current literature in this area is limited given challenges with physical activity measurement and inconsistencies in reporting participation rates. There is also a lack of data about physical activity participation rates among persons with SCI in low- and middle-income countries as all existing studies have been conducted in high-income countries. Further, most of the available data reports on aerobic-based activity, which only represents one type of physical activity. Additional measurement and reporting of strength-based physical activity participation at a population level is required.

Next, we review studies that have aimed to identify demographic, psychosocial, environmental and other factors that may correlate with physical activity participation, as well as studies in which participants have been asked to identify their physical activity barriers and facilitators. The myriad factors influencing physical activity participation operate at different levels of influence: intrapersonal, interpersonal, institutional/organizational, community, and policy levels. A considerable volume of evidence exists in this area from high-income countries, with few studies from middle income and no studies from low-income countries. In low- and middle-income countries, future research needs to explore the correlates, barriers and facilitators to physical activity participation for persons with SCI. In high-income countries, researchers should extend beyond describing factors influencing physical activity participation to planning, executing and evaluating interventions that target correlates, alleviate barriers, and leverage facilitators already identified in the literature.

Subsequently, we review intervention studies designed to increase physical activity participation among persons with SCI. Interventions to increase physical activity-related psychosocial variables and participation have largely used behavioural strategies, with several studies using informational strategies independently or in conjunction with behavioural strategies. All included intervention studies were from high-income countries. Future research should consider the extent to which theory is used in intervention design and evaluation and the influence of other intervention features (e.g., tailoring, dose, delivery mode, provider) on intervention impact. In addition, follow-up assessments are required to examine the long-term impact of interventions on relevant outcomes.

The module ends with an exploration of efforts to support dissemination and implementation of physical activity among persons with SCI. Physical activity intervention research in community and clinical settings is in its infancy. Five evidence-informed tools to support dissemination and implementation of these interventions were identified. Future research in physical activity dissemination and implementation should incorporate the use of implementation frameworks/theories and adopt SCI-specific guiding principles for integrated knowledge translation (i.e., collaborating with stakeholders and end users at all stages of project design where appropriate). To move towards addressing physical activity behaviour in the routine management of SCI, strategies are needed to support health professionals in developing their knowledge, confidence, and skill-set to apply behavioural techniques and engage in self-management support for individuals with SCI.

2 Introduction

Routine participation in physical activity is important for the physical health and psychosocial well-being of people living with SCI. Several systematic reviews have documented fitness, health and subjective well-being benefits of routine physical activity participation for adults with SCI (Neefkes-Zonneveld et al. 2015; Tomasone et al. 2013; van der Scheer et al. 2017). However, because people with SCI face tremendous barriers to physical activity, most do not reap the full benefits.

In order to support and improve physical activity participation in adults with SCI, it is important to first understand typical activity levels and patterns within this population. It is also necessary to understand factors that facilitate and hinder physical activity participation. With an understanding of these factors, interventions can then be developed to target those facilitators and barriers, with the goal of increasing physical activity participation.

In this module, we review studies that have measured the amount of physical activity performed by adults with SCI. Next, we review studies that have aimed to identify demographic, psychosocial, environmental and other factors that may correlate with physical activity participation and studies in which participants have been asked to identify their physical activity barriers and facilitators. Finally, we review intervention studies that were designed to increase physical activity participation, and explore tools to support implementation and dissemination of physical activity initiatives and programs among persons with SCI.

2.1 Physical Activity Definitions

Physical activity is an umbrella term that refers to any type of bodily movement, produced by skeletal muscles, that results in energy expenditure (Caspersen et al. 1985). This umbrella term includes all types of physical activity; these can be broadly categorized as leisure, transport, household, education, and occupational activities. Within the context of spinal cord injury, most of the research and clinical focus has been on physical activities that people perform in their leisure time, particularly exercise and sport.

Exercise is a subcategory of physical activity that is defined as "planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness" (Caspersen et al. 1985). Physical fitness refers to a set of attributes that relate to one's ability to perform physical activities and includes muscular strength and endurance, cardiorespiratory fitness, body composition, and flexibility. Simply stated, exercise is physical activity that people typically do with a plan in mind, and that they perform on a repeated basis to improve some aspect of their physicality.

Sports are also typically planned and structured activities that may be performed to achieve improvements in fitness. But unlike exercise, sports have a competitive element. This element provides the definitional distinction between sport and exercise activities.

Other types of physical activity, such as transportation activity (e.g., walking or handcycling to school), household activity (e.g., vacuuming the floor), or occupational activity (e.g., lifting and carrying boxes at work) might also improve physical fitness. However, for the most part, these types of physical activities are not widely performed by people with SCI at a duration or intensity that would be expected to confer fitness or health benefits (Perrier et al. 2017). There is also some uncertainty as to whether occupational and household physical activities confer the same fitness and health benefits as leisure-time physical activities (Holtermann & Stamatakis, 2019). For these reasons, the focus of most of the research literature, and this module, is on leisure-time physical activities.

Here are definitions of terms used within this module:

- Aerobic activities: physical activities that are done continuously and that increase the participant's heart and breathing rate (e.g., wheeling, swimming, hand cycling, dancing).
- Exercise: "planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness" (Caspersen et al. 1985).
- Flexibility: an aspect of physical fitness that refers to the range of motion at a joint (Caspersen et al. 1985).
- Leisure time physical activity: Physical activity that people choose to do during their free time. The types of activities that are done in leisure-time likely vary across cultures, but would typically include exercise, sports, and active play (including with children or pets). Here are examples of leisure-time physical activities reported by people with SCI in a large Canadian sample (Martin Ginis, Latimer, et al. 2010):
    - Wheeling (i.e., self-propelling one's own wheelchair)
    - Arm/Hand cycling
    - Resistance training
    - Walking
    - Playing sports such as wheelchair basketball, wheelchair rugby, sledge hockey, wheelchair tennis, bocce, and wheelchair curling
    - Gardening
    - Woodworking

  - Taking the dog for a walk
  - Playing with children
  - General fitness activities such as yoga, aerobic fitness classes, and tai chi
  - Fishing
  - Standing
  - Swimming

- Neuromotor: pertaining to, or affecting the effects of neurons on muscles. In other words, activities that may affect balance, coordination, agility, gait and proprioception (Bushman, 2012).
- Physical inactivity: An insufficient physical activity level to meet present physical activity recommendations (Tremblay et al. 2017).
- Rehabilitative exercise: These are exercises performed to restore function or movement and are typically performed in a rehabilitation setting (e.g., physiotherapy clinic). While similar to 'exercise,' these activities may not necessarily improve physical fitness. For instance, rehabilitative exercises such as practicing wrist flexion and extension may help improve hand function, but will not necessarily lead to increases in strength or endurance.
- Resistance exercise or Muscle strengthening activities or Strength training activities: "movement using body weight or external resistance that improves muscular strength, power, or endurance, and may ultimately positively impact mobility, function, and independence" (Chan et al. in press).
- Sedentary behaviour: any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture. For people who use a manual wheelchair or a power chair: Use of electronic devices (e.g., television, computer, tablet, phone) while sitting, reclining or lying; reading/writing/drawing/painting/talking while sitting; sitting in a bus, car or train; moving from place to place in a power chair; being pushed while passively sitting in a manual wheelchair (Tremblay et al. 2017).

2.2 Physical Activity Participation Levels

When compared with both the general population and people with other types of disabilities and chronic conditions, people with SCI are considered to be at the lowest end of the physical activity spectrum (van den Berg-Emons et al. 2010). Surprisingly few studies have actually measured physical activity in the SCI population. This lack of research is partly due to the challenges of measuring physical activity in people with SCI.

Physical activity measures used in SCI research can be categorized as technological/wearable measures or self-report measures. Technological or wearable measures are devices such as accelerometers, heart rate monitors, odometers, and other sensor-based devices that are attached to the person and/or their wheelchair. Technological/wearable measures have the advantage of being able to capture data over a long duration but are often limited by their inability to provide valid and reliable measures of the different types and intensities of activity performed by people with SCI. For instance, technological measures typically cannot distinguish between wheeling along a flat, even surface versus wheeling up steep, gravelly inclines. These two activities require different levels of effort and energy expenditure, so it is important to be able to distinguish between them in order to accurately measure physical activity. Similarly, wearable measures such as wrist-worn accelerometers or heart-rate monitors cannot reliably measure resistance exercise activities (e.g., lifting weights) or water-based activities such as swimming because most devices cannot be worn in the water. Another limitation of most technological measures is that they do not distinguish between leisure time physical activities and other types of physical activity (e.g., occupational, household). A further limitation is cost and convenience; it is challenging for researchers to use these types of measures in large, population-based studies of people with SCI because the devices can be expensive and difficult to distribute and retrieve from study participants.

Self-report measures of physical activity have the benefit of being inexpensive and relatively easy to administer in large samples of people with SCI. When people self-report their activity levels, researchers are able to categorize the activities as leisure time, or other types of activity (e.g., household, occupational). However, a major limitation of self-report measures is that they are susceptible to recall biases. Respondents may have difficulties remembering how much activity they performed and at what intensity. Activities that are done over a longer time with lots of stops and starts (e.g., playing wheelchair rugby, gardening) might present a challenge for remembering the amount of time spent resting versus active, so respondents may over-report time spent on these types of activities. People might also self-report the perceived intensity of an activity to be different from the actual, physiological intensity, or worry about giving 'good' responses and adjust their reports of activity time or intensity to what they think the researcher wants to hear.

In Table 1, we summarize studies that have descriptively reported physical activity levels in a sample of people with SCI.

Table 1. Studies Measuring Physical Activity in People With SCI

Author Year Country Research Design Score Total Sample Size	Methods	Outcome
de Groot et al. (2020) Netherlands Observational N=96	**Population:** Gender: males=72, females=24; Mean age=47.8yr; Injury: SCI=57, amputation=14, spina bifida=2, other=19; Mean time since injury=13.2yr. **No Intervention:** Participants completed a survey which concerned the benefits of participating in the HandbikeBattle event, current sport participation, and experienced barriers and	1. The median amount of participation in sport was 5.0hr/wk for those currently involved in sport.

	facilitators regarding current sport participation. **Outcome Measures:** Experienced benefits/losses (fitness, health, handcycling, performance activities in daily life, personal development), exercise and sports participation (average hr per week during last 3mo), experienced barriers and facilitators (personal barriers, environmental barriers, personal facilitators, environmental facilitators).	
Kooijmans et al. (2020) Netherlands Observational N=268	**Population:** Mean age: 47.7yr; Gender: males=197, females=71; Motor complete SCI=221; Mean time since injury: 24yr. **No Intervention:** Participants completed two questionnaires during an aftercare SCI check-up within one day. **Outcome Measures:** Spinal Cord Independence Measure III (SCIM-III), Physical Activity Scale for Individuals with Physical Disabilities.	1. Mean and median MET score for physical activity were 19.4±20.6 and 12.7, respectively.
Postma et al. (2020) Netherlands Observational $N_{Initial}$=47, N_{Final}=38	**Population:** Mean age: 54.5yr; Gender: males=25, females=22; Injury: Tetraplegia AIS C=1, Tetraplegia AIS D=22, Paraplegia AIS C=3, Paraplegia AIS D=21; Mean time since injury: 89.6d. **No Intervention:** Participants wore an Activ8 sensor and were evaluated 2wk prior to discharge and at 6mo and 1 year post discharge from inpatient rehabilitation to evaluate changes in duration of physical activity and sedentary behavior. **Outcome Measures:** Level of physical activity and Sedentary Behaviour (measured with Activ8 sensor(s)).	1. The duration of physical activity and sedentary behavior changed between discharge and 6mo by 21min/d (p=0.004) and -64min/d (p<0.001), respectively. It remained stable from 6mo to 1yr. 2. Mean physical activity at 1yr post discharge was 116±59min/d, with 21% being active <60min/d. 3. The duration of walking and standing increased in the first half year, while wheeling and maneuvering decreased (p<0.01). 4. Walking intensity was the only outcome that increased in the second half year (p=0.044) 5. Duration of running, cycling, prolonged bouts, and fragmentation indexes did not change over time (p>0.05).
Santino et al. (2020) Canada Observational N=170	**Population:** Age: <55yr=54, >55yr=116; Gender: males=136, females=34; I Injury: Incomplete paraplegia=40, Complete paraplegia=40, Incomplete tetraplegia=58, Complete tetraplegia=30,	1. The mean minutes per week of moderate and heavy leisure time physical activity was 255.25±457.59.

	missing=2; Time since injury: <10yr=48, 10+yr=122. **No Intervention:** Participants completed various measures during a telephone interview. **Outcome Measures:** Leisure Time Physical Activity Questionnaire for People with SCI, UCLA Loneliness Scale, Life Satisfaction Questionnaire.	
Jorgensen et al. (2017) Sweden Observational N=119	**Population:** Mean Age=63.5±8.7yr; Gender: Males=84, Females=35; Level of Injury: C1-L5; Severity of Injury: AIS A-C=60, D=59; Mean Time Since Injury=23.9±11.7yr. **No Intervention:** Review of data from the Swedish Aging with SCI Study to assess participation in leisure time physical activity (LTPA) among older adults with long-term SCI. **Outcome Measures:** Physical activity recall assessment for people with SCI (PARA-SCI), intensity, type and duration of physical activity.	1. The mean minutes per day of total LTPA were 34.7, while moderate-to-heavy was 22.5.
Montesinos-Magraner et al. (2018) Spain Observational N=67	**Population:** Complete motor SCI (T2-T12). *Inactive group (n=30):* Mean age: 50.63yr; Gender: males=20, females=10; Mean time since injury: 15.77yr. *Active group (n=37)*: Mean age: 43.4yr; Gender: males=31, females=6; Mean time since injury: 17.76yr. **No Intervention:** Participants who were full time manual wheelchair users, wore an accelerometer attached to their non-dominant wrist for a period of 1 week (actigraph model GT3X). Participants were divided into active (at least 60min moderate to vigorous physical activity per week) or inactive groups. **Outcome Measures:** Physical activity levels, risk factors for metabolic syndrome.	1. The inactive group, compared to the active group, had significantly less METS (MD -0.13), and less minutes per day of light (-95.73), moderate (-22.89) and moderate-to-vigorous (-23.10) activity (all p<0.001), as well as vigorous exercise (-0.21, p=0.04).
Perrier et al. (2017) Canada Observational N=695	**Population:** Mean age: 46.81±13.41yr; Gender: males=528, females=167; Injury etiology= Traumatic, Mean time since injury: 15.19yr±11.10yr.	1. Participants reported an average of 127.92±142.79 min per day of total daily activities, with significantly more minutes per day spent on mild-intensity

	No Intervention: Cross sectional analysis to examine daily activity time. **Outcome Measures:** Daily self-reported activity time across 36 different activities that did not include LTPA. Relationships between variables and activity time.	(78.93±104.62 min per day) than moderate-intensity (40.23±68.71 min per day, t= 9.06, Po0.0001) or heavy-intensity activities (8.75±24.53 min per day, t=17.33, Po0.0001).
Rocchi et al. (2017) Canada Observational N=73	**Population:** Mean age: 52.99yr; Gender: males=54, females=18, undisclosed=1; Level of injury: Paraplegia=41, Tetraplegia=28, undisclosed=4; Level of severity: AIS A=,33 AIS B=10, AIS C=13, AIS D=15; Mean time since injury: 19.99yr. **No Intervention:** Individuals completed a questionnaire by telephone. The questionnaire was completed twice, once in response to aerobic activities and one for resistance activity. Physical activity levels were compared to SCI specific physical activity guidelines. Aerobic guideline was at least 2 sessions (at least 20min each) of moderate to vigorous intensity aerobic activity in last 7 days. The resistance guideline was similar (2 sessions in last 7 days). **Outcome Measures:** Leisure Time Physical Activity Questionnaire for People with SCI (LTPAQ-SCI), Treatment Self-Regulation for Exercise Questionnaire.	1. Twelve percent of participants met the guidelines, and 44% reported 0 min of physical activity. 2. Participants reported 27.15±55.64 min/wk. of moderate aerobic physical activity and 11.68±25.02 min/wk. of vigorous aerobic activity. 3. Participants reported 11.42±25.04 min/wk. of moderate resistance physical activity and 2.30±9.13 min/wk. of vigorous resistance physical activity.
Rauch et al. (2016) Switzerland Observational N=485	**Population:** Mean age: 52.9yr; Gender: males=357, females=128; Severity of SCI: Complete paraplegia=159, Incomplete paraplegia=169, Complete tetraplegia=55, Incomplete tetraplegia=100, missing=2; Mean time since injury: 17.3yr. **No Intervention:** Participants completed a survey examining physical activity levels. **Outcome Measures:** Four items from the Physical Activity Scale for Individuals with Physical Disabilities, Spinal Cord Independence Measure.	1. Among all participants, 18.6 % were physically inactive, 50.3 % carried out muscle-strengthening exercises, and 48.9 % fulfilled the World Health Organization (WHO) recommendations. 2. The median total time for all physical activities per week was 6.0hr. 3. Participants spent the most time (median 2.2hr) performing sports of light intensity. 4. Participants with complete paraplegia, manual wheelchair users, and time since injury 16-25yr spent the most median time on sports of moderate intensity.

Flank (2014) Sweden Cross-sectional N=134	**Population:** Age=47.8±13.8yr.; Gender: males=103, females=31; Level of injury: T1-T6=34, T7-L4=66; Level of severity: Not reported; Time since injury=18.5±12.3yr. **No Intervention:** cross-sectional. Participants had their self-reported physical activity assessed to determine its influence on risk markers for cardiovascular disease (CVD). **Outcome Measures:** Physical activity (PA), Body Mass Index (BMI), Blood Pressure (BP - Systolic & Diastolic), Blood glucose (BG), Total Cholesterol ((TC) High Density Lipoprotein (HDL), Low Density Lipoprotein (LDL)), Triglycerides (TG).	1. 1 in 5 persons reported completing ≥30min of PA per day. 2. Comparison of CVD risk markers between the persons fulfilling the criteria or not showed significant differences regarding BP, and a trend toward significant differences regarding BMI and LDL/HDL ratio. 3. Older age correlated with lower level of self-reported PA with the amount of PA (p=0.047), and with the amount of moderate/vigorous physical activity (MVPA) (p=0.005). 4. Those who were physically active ≥30min per day were significantly younger than those who were inactive (p=0.001). 5. No significant differences between the physically active and on-active group concerning socioeconomic factors in the study.
Kroll et al. (2012) UK Observational N=612	**Population:** Mean age: 48.5yr; Gender: males=386, females=226; Paraplegia=300; Complete SCI=356; Mean time since injury: 15.88yr. **No Intervention:** Participants completed mail-in surveys over 2yr examining exercise self-efficacy and exercise behaviour. **Outcome Measures:** Exercise frequency and intensity, Exercise Self-Efficacy Scale.	1. Participants engaged in aerobic exercise, on average, 2.4±2.3d/wk and resistance training 2.15±2.14d/wk. 2. Participants, on average, rated their aerobic and resistance training intensity to be moderate.
Ishikawa et al. (2011) USA Observational N=11	**Population:** Age=49.3±13.7yr.; Gender: males=7, females=4; Level of injury: C=5, T=4, L=2; Level of severity: ASIA A=0, B=0, C=9, D=2; Time since injury=4.9±7.7yr. **No Intervention:** observational. Participants wore a StepWatch Activity Monitor during waking hours for 7 consecutive days. **Outcome Measures:** Daily Step Activity (DSA), Variance in DSA.	1. Overall mean number of steps per day was 1281±1594.
De Groot et al. (2011) Netherlands Cross-sectional N=139	**Population:** Age=41.6±14.1yr.; Gender: males=101, females=38; Level of injury: paraplegia=95, quadriplegia=43; Level of severity: complete=89, incomplete=50; Time since injury=7.5±169days.	1. Total mean PASIPD score across 139 participants was 17.8 (18.6) MET hr/day (range of 0 - 74.4). 2. Those with tetraplegia or long TSI (long: TSI>672 days) had significantly lower PASIPD scores

	No Intervention: cross-sectional. Participant's physical activity was measured using the physical activity scale for individuals with physical disabilities (PASIPD) 1 year after discharge from in-patient rehabilitation and results were compared between those with paraplegia and those with tetraplegia or lost. **Outcome Measures:** Physical activity scale for individuals with physical disabilities (PASIPD), The Wheelchair Circuit, Utrecht Activities List (UAL),	compared with those with paraplegia (p=0.02) or those with short TSI (p=0.03). 3. Completeness of the lesions did not lead to significantly different PASIPD score (p=0.97). 4. Moderate correlations were found between the PASIPD total score and activities (p<0.01). 5. PASIPD total score revealed weak correlations between most physical capacity measures, except the manual muscle test (MMT) sum, which showed a moderate correlation. 6. Strong correlation was found between strenuous sport or recreational activities and the number of hours per week a person participates in sport activities (measured by UAL). 7. Weak correlations were found between light and moderate sport or recreational activities and VO2peak or POpeak, and between muscle strength training and muscle strength measured by MMT or handheld dynamometry.
Martin Ginis, Latimer, et al. (2010) Canada Cross-Sectional N=695	**Population:** Mean age:47.1±13.5yr; Gender: males=531, females=164; Mean time post-injury: 15.3±11.1yr **No Intervention:** Data on physical activity and demographic/injury-related characteristics of SCI patients were collected through telephone interviews. **Outcome Measures:** Physical Activity Recall Assessment for Persons with Spinal Cord Injury (PARA-SCI).	1. Respondents reported a mean of 27.14±49.36 minutes of LTPA a day. 2. 50.1% of participants reported no LTPA whatsoever. 3. Highest amounts of daily LTPA (≥21min/d) were associated with manual wheelchair use and T1 to S5, AIS grade A to C injury. 4. Moderate LTPA (1–20min/day) was most associated with being female, 5 to 10 years post injury, and 21 to 33.8 years of age. 5. Inactivity (0min/d) was most associated with being male, greater than or equal to 11 years post injury, and greater than or equal to 33.8 years of age.
Martin Ginis, Arbour-Nicitopoulos, et al. (2010) Canada	**Population:** A subset of participants in the SHAPE-SCI study who reported at least some LTPA. Mean age: 45.4±13.8yr; Gender: males=270, females=77; Mean time post-injury: 13.5±10.0yr.	1. Participants reported 55.15±59.05min/day of LTPA at a mild intensity or greater. Median LTPA was 33.33min/d. 2. Participants engaged and spent significantly more time on

Cross-Sectional N=347	**No Intervention:** Data on physical activity was collected through telephone interviews. **Outcome Measures:** Physical Activity Recall Assessment (PARA-SCI). This was broken down by type and intensity of activity.	moderate intensity LTPA than mild or heavy intensity LTPA, and more time on mild LTPA than heavy intensity LTPA. 3. Resistance training, aerobic exercise, and wheeling were the most frequently reported, whereas sports and craftsmanship activities were performed for the longest durations. 4. Activity duration differed as a function of activity intensity for resistance training, wheeling, craftsmanship, walking, play, and standing. 5. Resistance training was done for more minutes at a moderate intensity than at heavy and mild intensities, and for more minutes at a heavy intensity than a mild intensity. 6. Craftsmanship, play, and wheeling were performed for more minutes at a mild or moderate intensity than at a heavy intensity. 7. Walking and standing were done for more minutes at a moderate intensity than a heavy intensity. 8. Resistance training, aerobic exercise, and general fitness activities were more likely to be performed at a moderate or heavy intensity than a mild intensity. 9. There was no difference in the rate of participation in mild, moderate, or heavy intensity sport activities or in the amount of time spent performing mild, moderate, or heavy intensity activity for the general fitness activities, gardening, swimming, sports, or aerobic exercise.
Tawashy et al. (2009) Canada Cross-sectional N=49	**Population:** Age=43.7±11.7yr.; Gender: Not reported; Level of injury: paraplegia=33, tetraplegia=16; Level of severity: complete=30, incomplete=19; Time since injury=11.8±9.2. **No Intervention:** Cross-sectional. Participants completed the physical	1. No significant correlations were found between physical activity and any demographic factors (p>0.05 for all). 2. No influence of sex or lesion level on physical activity participation. 3. Physical activity was significantly related to secondary complications fatigue severity for heavy intensity

	activity recall assessment for people with Spinal Cord Injury (PARA-SCI). **Outcome Measures:** Physical Activity Recall Assessment for people with Spinal Cord Injury (PARA-SCI), Instrumental Support Evaluation List (ISEL), Standford Self-Efficacy for Managing Chronic Disease Scale (ESE), Fatigue Severity Scale (FSS), Graded Chronic Pain (GCP), Centre for Epidemiological Studies – Depression (CES-D).	(p<0.01), self-efficacy for heavy (p<0.01) and total PARA-SCI scale (p<0.05), GCP for heavy (p<0.05) and mild intensity (p<0.05), ISEL for mild intensity (p<0.05), and CES-D for mild (p<0.01) and total PARA-SCI score (p<0.05).
Stevens et al. (2008) USA Cross-sectional N=62	**Population:** Age=35±10yr.; Gender: males=32, females=30; Level of injury: paraplegia=39, tetraplegia=23; Level of severity: complete=38, incomplete=24; Time since injury=9±9yr. **No Intervention:** Cross-sectional. Participants completed two surveys, the Quality of Well-Being Scale and the Physical Activity Scale for Individuals with Physical Disabilities to document the relationship between level of PA and QoL. **Outcome Measures:** Quality of Well-Being Scale (QoWBS), Physical Activity Scale for Individuals with Physical Disabilities (PASIPD).	1. The mean PASIPD score was 26.40±8.32. 2. Significant positive association between level of physical activity and quality of life was observed (p<0.05). 3. When physical activity, anatomical location of the injury, completeness of injury, and time since injury were used as explanatory variables, level of physical activity was the only significant predictor of QoL.
Van den Berg-Emons et al. (2008) The Netherlands Observational $N_{Initial}$=36 N_{Final}=16	**Population:** T1: Mean age: 42.1yr; Gender: males=28, females=8. T5 (n=16): Mean age: 42.2yr; Gender: males=14, females=2. **No Intervention:** Participants' physical activity level was monitored 2 consecutive weekdays every assessment period using an activity monitor. Data was collected at the start of inpatient rehabilitation (T1), 3 months later (T2), at discharge from inpatient rehabilitation (T3), and 2 months (T4) and 1 year post discharge (T5). **Outcome Measures:** Physical activity level based on accelerometry-based activity monitor.	1. The duration of dynamic activities and the intensity of everyday activity increased during inpatient rehabilitation at rates of 41% and 19%, respectively (P<0.01). 2. Shortly after discharge, there was a strong decline (33%; P<0.001) in the duration of dynamic activities. 3. One year after discharge, the duration of dynamic activities was restored to the discharge level (3.4%±3.3%; corresponding with 49min/d), but was significantly lower (p<0.001) compared to the levels in able-bodied persons (9.9%±4.1%; corresponding with 143min/d).
Buchholz et al. (2003) Canada Cross-Sectional	**Population:** *Men* Age=38.7±10.7yr.; n=17; Level of injury: paraplegia=17, quadriplegia=0; Level of severity: Not reported; Time since	1. Fifteen participants (56%) engaged in structured physical activity 1.46±0.85 times during the

N=27	injury=10.4±8.1yr. *Women* Age=31.7±6.0yr.; n=10; Level of injury: paraplegia=10, quadriplegia=0; Level of severity: Not reported; Time since injury=16.1±11.1. No Intervention: Cross-sectional. Participants wore a heart rate monitor (HRM) and had outcome measures taken/calculated and results were compared to the World Health Organization recommendations and between persons with complete vs. incomplete paraplegia. Outcome Measures: Heart Rate (HR), Total Daily Energy Expenditure (TDEE), Physical Activity Level (PAL), Energy Intake (EI)	observation period for a mean of 49.4±31.0 minutes. 2. Mean PAL of the group was 1.56±0.34 bouts, indicative of limited physical activity. 3. TDEE was 24.6% lower in participants with complete paraplegia (2072±505 vs. 2582±852 kcal/d, p=0.0372). 4. No differences in FLEX HR (p=0.5965) or mean daily HR (p=0.5645) between those with complete or incomplete SCI. 5. No significant difference between those with complete or incomplete SCI for TDEE using the Student's *t* test (p=0.1611). 6. No association between since onset and TDEE (p=0.6591) or PAL (p=0.9547). 7. EI was significantly underreported overall (p=0.0320).

In the reviewed studies, the physical activity estimates are likely influenced by how physical activity was defined and measured. In some of the reviewed studies, physical activity was defined narrowly (e.g., participation in sports activities or exercise activities); in others it was defined broadly to capture participation in all activities requiring physical exertion (e.g., leisure-time physical activity, activities of daily living). Some studies reported physical activity of a particular intensity (e.g., mild, moderate, heavy) and others reported on total physical activity, regardless of intensity. These differences introduce considerable variability into the reported estimates of physical activity participation and make it difficult to compare the results across samples and studies. All of the studies were conducted in high income countries (particularly Canada, US, UK and European countries). We have virtually no information on physical activity participation by people with SCI living in low- and middle-income countries.

All of the larger-sample studies (n > 70) utilized self-report measures of physical activity, with considerable variability in the types and amounts of physical activity information collected. This information ranged from simply the rate of participation in the sample (e.g., percentage who achieved physical activity guidelines), to more comprehensive data on the types of physical activities performed, and in some cases, participation frequency, duration, and intensity. In studies that used technological measures, the data were reported as time spent on activity, movement behaviours (e.g., number of steps walked), energy expenditure (expressed as METs or metabolic equivalents) or percentage of time spent active. Again, these differences in reporting methods create variability in estimates and make it difficult to compare findings across studies.

Regardless of how physical activity was measured, overall, the studies indicated low average daily and weekly amounts of physical activity in samples of people with SCI. It is important to note, however, that the standard deviations were very large-- typically 1 to 2 times the size of the mean (Martin Ginis, Latimer, et al. 2010; Rocchi et al. 2017; Saori Ishikawa, 2011). This is an important observation that highlights the tremendous variability in physical activity participation among people with SCI.

Furthermore, large proportions of people with SCI (up to 50%) did no leisure-time physical activity whatsoever. This is an important finding to keep in mind when developing physical activity-enhancing interventions. There are at least two large sub-groups within the SCI population; a completely inactive sub-group and a sub-group that varies from minimally active to highly active (Martin Ginis, Arbour-Nicitopoulos, et al. 2010). These different groups will require different interventions.

A couple of studies looked at whether people with SCI were meeting physical activity guidelines. Of note, while both the WHO (Bull et al. 2020) and the SCI exercise guidelines (Martin Ginis et al. 2018) emphasize the importance of aerobic and strength training exercise, we have very little data specifically on the amount of strength training activity performed. Most of the studies report only on aerobic activities (e.g., minutes spent walking or wheeling) or aerobic and strength training activities are combined (e.g., in studies that use technological measures, or a self-report measure of total time spent on exercise or leisure-time physical activities). Going forward, attention is needed to measure participation in both types of exercise prescribed in the guidelines.

With a couple of exceptions (Tawashy et al. 2009), most of the measurement studies have been conducted among people with chronic SCI, who are living in community settings. van den Berg-Emons et al. (2008) conducted a study in which physical activity was measured at the start of in-patient rehabilitation, at discharge, and 2-months and 1-year after discharge. This study demonstrated the sharp decline in physical activity from the in-patient phase to 1-year post discharge, emphasizing the need to monitor physical activity and to intervene and provide supports to sustain activity across in-patient/out-patient transitions and phases.

3 Increasing Physical Activity Participation

Increasing physical activity participation among persons with SCI requires systematically targeting the factors that influence participation. These factors include correlates (or predictors) of physical activity participation that can be targeted in a given intervention, as well as physical activity barriers that can be mitigated, and/or facilitators that can be emphasized, in a given intervention. In the past decade, the examination of physical activity correlates and barriers/ facilitators has burgeoned, and there has been a concomitant increase in the development and evaluation of physical activity-enhancing interventions. Research exploring translation of physical activity interventions in community and clinical settings is also garnering attention.

This section begins by reviewing the correlates of physical activity participation and barriers and facilitators to physical activity participation among persons with SCI. Next, we review the impact of interventions that aim to increase physical activity-related psychosocial variables and participation among persons with SCI. We end this section with an overview of knowledge translation of physical activity promotion in the SCI community.

3.1 Correlates of Physical Activity Participation and Barriers/Facilitators to Physical Activity

In order to tailor physical activity-enhancing interventions to the needs of individuals with SCI, it is necessary to understand the factors that facilitate and hinder their participation. Dozens of studies have been conducted to (a) test for predictors or correlates of physical activity participation and (b) generate lists of barriers and facilitators to physical activity experienced by people with SCI and other disabilities (Martin Ginis et al. 2016; Martin Ginis et al. 2021). The objective of this section is to summarize this literature.

In *Table 2*, we have synthesized the results of studies that have used quantitative methods and statistics to examine the strength of relationships (i.e., correlations) between factors that could be related to physical activity and a measure of physical activity participation. In *Table 3*, we have synthesized descriptive information from studies in which participants were explicitly asked about barriers and facilitators to physical activity, but there was not a statistical test of the relationship between these factors and physical activity participation.

Table 2. Studies Reporting Quantitative Correlates of Physical Activity Participation Among Persons With SCI

Author Year Country Research Design Score Total Sample Size	Methods	Outcome
Kooijmans et al. (2020) Netherlands Observational N=268	**Population:** Mean age: 47.7yr; Gender: males=197, females=71; Motor complete SCI=221; Mean time since injury: 24yr. **No Intervention:** Participants completed two questionnaires during an aftercare SCI check-up. **Outcome Measures:** Spinal Cord Independence Measure III (SCIM-III), Physical Activity Scale for Individuals with Physical Disabilities.	1. Exercise self-efficacy was significantly related to the level of daily physical activity (β=0.05; 95% CI 0.04–0.07; 15% explained variance; p<0.001) based on a univariate regression analysis. 2. There was a significant association between self-efficacy and performing sports activities (LOG β = 0.04, 95% CI 0.03–0.06), as well as daily activities that are not sports related (LOG β = 0.01, 95% CI 0.02–0.05).
Hansen et al. (2020) Denmark Observational N=181	**Population:** Mean age: 48±14yr; Gender: males=86, females=95; Level of injury: tetraplegia=22, paraplegia=81, unknown=11; Level of severity: complete=59, incomplete=50, unknown=5. **No Intervention:** Manual wheelchair users (MWCUs) completed a 15-20min survey containing three	1. There were no significant differences in any demographic variables between participants (p>0.162). 2. The 5 most prevalent barriers included 2 intrapersonal and 3 community barriers.

	sections: demographic information, self-reported physical activity level (PAL), and perception of barriers to physical activity participation. **Outcome Measures:** Barriers to Physical Activity Questionnaire for People with Mobility Impairments (BPAQ-MI).	3. The 5 most severe individual barriers included 1 organizational and 4 community barriers. 4. PAL was inversely associated with total intrapersonal (r=-0.487, p<0.01) and overall (r=-0.241, p<0.01) impact and the intrapersonal “health” (r=-0.477, p<0.01) and “beliefs/attitudes” (r=-0.307, p<0.01) subdomains. 5. The “health” subdomain impact score was independently associated with PAL (p<.001).
Postma et al. (2020) Netherlands Observational $N_{Initial}$=47, N_{Final}=38	**Population:** Mean age: 54.5yr; Gender: males=25, females=22; Injury: Tetraplegia AIS C=1, Tetraplegia AIS D=22, Paraplegia AIS C=3, Paraplegia AIS D=21; Mean time since injury: 89.6d. **No Intervention:** Participants wore an Activ8 sensor and were evaluated 2wk prior to discharge and at 6mo and 1 year post discharge from inpatient rehabilitation to evaluate changes in duration of physical activity and sedentary behavior. **Outcome Measures:** Level of physical activity.	1. The duration of physical activity and sedentary behavior changed between discharge and 6mo by 21min/d (p=0.004) and -64min/d (p<0.001), respectively. It remained stable from 6mo to 1yr. 2. Largest proportion of physical activity was walking which increased over time from 60% to 84%, while wheeling decreased from 24% to 3%. 3. Mean physical activity at 1yr post discharge was 116±59min/d, with 21% being active <60min/d. 4. Older age and lower ambulation level were associated with lower physical activity (p<0.05). 5. Lower ambulation level with higher sedentary behavior and tetraplegia were associated with reduced increase in physical activity.
Santino et al. (2020) Canada Observational N=170	**Population:** Age: <55yr=54, >55yr=116; Gender: males=136, females=34; I Injury: Incomplete paraplegia=40, Complete paraplegia=40, Incomplete tetraplegia=58, Complete tetraplegia=30, missing=2; Time since injury: <10yr=48, 10+yr=122. **No Intervention:** Participants completed various measures during a telephone interview. **Outcome Measures:** Leisure Time Physical Activity Questionnaire for People with SCI,	1. The mean minutes per week of moderate and heavy leisure time physical activity was 255.25±457.59.
Kazmierczak et al. (2018) Poland	**Population:** Mean age: 34.3yr; Gender: males=57, females=18; Level of injury:	1. From pre to post injury, 58.7% reported a decrease in LTPA, 24% no change and 17.3% an increase.

Observational N=75	cervical=25, thoracic=25, lumbar=25; Mean time since injury: 7.2yr. **No Intervention:** Participants completed a custom questionnaire pertaining to their leisure time physical activities (LTPA). Medical charts were also used to extract injury data. **Outcome Measures:** Frequency of LTPA, Barthel Index.	2. Based on level of injury, a decrease in LTPA was reported for 52% of the cervical group, 68% thoracic group and 56% lumbar group. 3. 65.3% of participants were currently practicing LTPA: 56% of cervical group, 60% of thoracic group and 80% of lumbar group. 4. 44% reported doing individual activities as LTPA, 16% both individual and group activities, and 5.3% group activities. 5. The time between SCI and commitment to LTPA was <1yr for 40%, 1-3yr for 20%, 4-5yr for 2.7% and >6 for 2.7% of participants. 6. 34.7% said it was their own decision to engage. 7. Frequency of LTPA for total sample was 3-4 times/wk for 32 and 2-4 times/wk for 11. 8. Of those working out 3-4time/wk, 9 were from the cervical group, 11 thoracic, and 12 the lumbar group. 9. Of those working 2-4 times/wk, 4 were from the cervical group, 1 thoracic and 6 lumbar. 10. Participants with higher physical independence (higher score in BI) engaged in physical exercises proportionality more often.
Ferri-Caruana et al.(2020) Spain Observational N=106	**Population:** *Exercise Group (n=63):* Gender: males=58, females=6; Mean age=38.81yr; Level of injury: T2-L5; Severity of injury: AIS A-B; Mean time since injury: 173.8mo. *Non-Exercise Group (n=42):* Gender: males=32, females=10; Mean age=46.24yr; Level of injury: T2-T5; Severity of injury: AIS A-B; Mean time since injury: 171.61mo. **No Intervention:** Participants completed the exercise motivations inventory questionnaire which assesses predisposing reasons for the practice of physical exercise. **Outcome Measures:** Exercise Motivations Inventory (EMI-2).	1. Participants in both the exercise and non-exercise group showed similar motivation towards exercise. 2. The most important motive to practice or to adhere to exercise was ill health avoidance, the second was fitness. 3. Motives that distinguished the exercise group from non-exercise group included enjoyment and revitalization (p<0.05), competition (p<0.05), and health pressure (p<0.01). 4. Motivation was found to relate to the type of physical exercise performed. 5. Sports players showed a significantly higher score for competition and enjoyment and

		revitalization than physical exercisers (p<0.05).
Taran et al. (2018) Canada Secondary analysis of Rocchi et al. 2017 N=56 *Subset of population from Rocchi et al. 2017	**Population:** Age=53.8±11.2yr.; Gender: males=41, females=15; Level of injury: paraplegia=33, tetraplegia=23; Level of severity: ASIA A=46%, B=14%, C=18%, D=21%, E=1%; Time since injury=20.6±13.7yr. **No Intervention:** Secondary analysis. Intervention completed in study being analyzed. **Outcome Measures:** Leisure Time Physical Activity Questionnaire (LTPAQ), Satisfaction with Life Scale (SWLS), Impact of pain.	1. After controlling for mobility, perception of the impact of pain was highly negatively associated with life satisfaction. 2. LTPA was associated with life satisfaction, accounting for an additional 13% of variance. 3. Standardized regression coefficient between perception of the impact of pain and life satisfaction did not change after adding LTPA to the model, which shows the independent association of LTPA and perception of pain with life satisfaction.
Jorgensen et al. (2017) Sweden Observational N=119	**Population:** Mean Age=63.5±8.7yr; Gender: Males=84, Females=35; Level of Injury: C1-L5; Severity of Injury: AIS A-C=60, D=59; Mean Time Since Injury=23.9±11.7yr. **No Intervention:** Review of data from the Swedish Aging with SCI Study to assess participation in leisure time physical activity (LTPA) among older adults with long-term SCI. **Outcome Measures:** Physical activity recall assessment for people with Spinal Cord Injury (PARA-SCI), intensity, type and duration of physical activity.	1. Of the total population, 29% reported no LTPA, while 53% performed moderate-to-heavy intensity LTPA. 2. The mean minutes per day of total LTPA where 34.7, while moderate-to-heavy was 22.5. 3. The most frequently performed activities were walking (32%), wheeling (25%) and general fitness (24%). 6. Sociodemographic, injury characteristics and secondary health conditions explained 10.6% and 13.4% of the variance in total and moderate-to-heavy LTPA. Age and wheelchair use were significantly, negatively associated with total LTPA (p<0.05). Women, wheelchair users and employed participants performed significantly less moderate-to-heavy LTPA than men, those using walking devices/no mobility device and unemployed participants (p<.05).
Perrier et al. (2017) Canada Observational N=695	**Population:** Mean age: 46.81±13.41yr; Gender: males=528, females=167; Injury etiology= Traumatic, Mean time since injury: 15.19yr±11.10yr. **No Intervention:** Cross sectional analysis to examine daily activity time. **Outcome Measures:** Daily self reported activity time across 36	1. Participants reported significantly more minutes per day spent on mild-intensity than moderate-intensity (p<0.0001) or heavy-intensity activities (p<0.0001). More minutes per day were also spent in moderate- versus heavy-intensity daily activities (p<0.0001).

	different activities. Relationships between variables and activity time.	2. There were significant between-group differences for education groups with regard to minutes per day of mild-intensity daily activities, p<0.01. There were also between-group differences for injury severity categories with regard to minutes per day of heavy-intensity activities, p< 0.01. Participants with an injury classified as AIS A–C, C1–C4 or AIS A–C, T1–S5 reported significantly fewer minutes per day of heavy-intensity activities than those classified as AIS D.
Rauch et al. (2017) Germany Observational N=485	**Population:** Mean age: 52.8yr; Gender: males=357, females=128; Injury: Incomplete paraplegia=169, Complete paraplegia=159, Incomplete tetraplegia=100, Complete tetraplegia=55, missing=2; Mean time since injury: 17.3yr. **No Intervention:** Secondary analysis of Swiss Spinal Cord Injury Cohort Study. **Outcome Measures:** Self-reported Spinal Cord Independence Measure, Physical Activity Scale for Individuals with Physical Disabilities, SF-36 five-item Mental Health Index, Nottwil Environmental Factors Inventory Short Form, Purpose in Life Test-Short Form.	1. Older age decreased, but being a manual wheelchair user increased the odds of being physically active and achieving the World Health Organization recommendations on physical activity. 2. Social support and self-efficacy increased odds of being physically active. 3. Use of intermittent catheter increased and dependency in self-care mobility and coping with emotions decreased odds for achieving the World Health Organization recommendations on physical activity.
Rocchi et al. (2017) Canada Observational N=73	**Population:** Mean age: 52.99yr; Gender: males=54, females=18, undisclosed=1; Level of injury: Paraplegia=41, Tetraplegia=28, undisclosed=4; Level of severity: AIS A=,33 AIS B=10, AIS C=13, AIS D=15; Mean time since injury: 19.99yr. **No Intervention:** Individuals completed a questionnaire by telephone. The questionnaire was completed twice, once in response to aerobic activities and one for resistance activity. Physical activity levels were compared to SCI specific physical activity guidelines. Aerobic guideline was at least 2 sessions (at least 20min each) of moderate to vigorous intensity aerobic activity in	1. Of the adults with SCI interviewed, 36% and 19% were meeting the aerobic and resistance guidelines, respectively. 2. 12% of the sample met both aerobic and resistance requirements. 3. 44% of the sample reported no physical activity at all. 4. No demographic or SCI characteristics predicted meeting the aerobic or resistance physical activity guidelines when compared with the no activity or some activity groupings. 5. Autonomous motivation was a significant correlate where individuals with an autonomous

	last 7 days. The resistance guideline was similar (2 sessions in last 7 days). **Outcome Measures:** Leisure Time Physical Activity Questionnaire for People with SCI (LTPAQ-SCI), Treatment Self-Regulation for Exercise Questionnaire.	motivation for physical activity were more likely to meet the guidelines than not. 6. Manual wheelchair users were more likely to meet both the aerobic and resistance guidelines compared to those reporting some activity.
Rauch et al. (2016) Germany Observational N=485	**Population:** Mean age: 52.9yr; Gender: males=357, females=128; Severity of SCI: Complete paraplegia=159, Incomplete paraplegia=169, Complete tetraplegia=55, Incomplete tetraplegia=100, missing=2; Mean time since injury: 17.3yr. **No Intervention:** Participants completed a survey examining physical activity levels. **Outcome Measures:** Four items from the Physical Activity Scale for Individuals with Physical Disabilities, Spinal Cord Independence Measure.	1. The median total time for all physical activities per week was 6.0hr. 2. Participants spent the most time (median 2.2hr) performing sports of light intensity. 3. Participants with complete paraplegia, manual wheelchair users, and time since injury 16-25yr spent the most median time on sports of moderate intensity. 4. Participation was lowest for strenuous sporting activities and muscle-strengthening exercises. 5. People 71 and older, women, people with complete tetraplegia and users of electric wheelchairs showed the lowest total physical activity times. 6. 18.6% of the sample was completely physically inactive. 7. 50.3% carried out muscle-strengthening exercises at least 1-2 days a week. 8. 48.9% of participants fulfilled the WHO recommendations for physical activity. 9. Women, people aged 71 and older, and people with complete tetraplegia had significantly lower odds of fulfilling the WHO recommendations than participants in the respective reference category (men, ages 17–30, incomplete paraplegia).
Zbogar et al. (2016) Canada Observational N=95	**Population:** Gender: males=68, females=27; mean age=49yrs; level of injury: paraplegia=53, tetraplegia=42; severity of injury: AIS A=23, B=12, C=12, D=48. **No Intervention:** Physical activity level at admission and discharge were recorded by self-report questionnaire	1. There was no statistically significant change over time in self-reported physical activity (PARA-SCI) minutes outside therapy for both paraplegia and tetraplegia at lower and higher intensities (median mins of physical paraplegia- higher

	(PARA-SCI) and real-time accelerometers worn on the dominant wrist or hip if ambulatory. **Outcome Measures:** Actical accelerometers (physical activity measure), Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI).	intensity: admission=555min, discharge=587min, lower intensity: admission=532min, discharge=565min; tetraplegia-higher intensity: admission=533min, discharge=556min, lower intensity: admission=489min, discharge=497min) (ps>0.05). 2. Significant increases in physical activity outside physical therapy and occupational therapy sessions from admission to discharge were found for wrist accelerometers for individuals with tetraplegia (from 62min at admission to 99min at discharge) and hip accelerometers for ambulatory individuals (from 0min at admission to 1097min at discharge; ps<0.0001).
Martin Ginis et al. (2017) Canada Observational N=347	**Population:** Mean age: 47.7yr; Gender: males=271, females=76; Level of injury: C1-C8=141, T1-S5=206; Mean time since injury: 16.1yr. **No Intervention:** Secondary analysis of Study of Health and Activity in Spinal Cord Injury (SHAPE-SCI) study. Participants completed a questionnaire at baseline pertaining to theory of planned behaviour constructs and at 6mo one for leisure time physical activity (LTPA). **Outcome Measures:** Theory of planned behavior constructs, the Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI).	1. At baseline, ambulators had poorer attitudes towards LTPA than manual chair users (p=0.004). No other differences were significant. 2. Among ambulators, perceived behavioural control was negatively related to LTPA (p<0.05), meaning ambulators with the greatest sense of control over LTPA did the least activity. 3. Attitudes had a significant indirect relationship with LTPA through intentions (p<0.05). 4. Among manual chair users, perceived behavioural control was not directly associated with LTPA but attitudes (p<0.01), subjective norms (p<0.05) and perceived behavioural control (p<0.01) were significant indirect predictors of LTPA through intentions.
Martin Ginis et al.(2013) Canada Observational N=238	**Population:** *Actors (n=105):* Mean age: 42.41±13.59yr; Mean time since injury: 11.29±8.60yr; Gender: males=80, females=25; Level of injury: paraplegia=53, tetraplegia=50; Level of severity: complete=34, incomplete=42. *Intenders (n=73):* Mean age: 45.07±11.69yr; Mean time since injury: 15.84±11.16yr; Gender: males=57, females=16; Level of injury: paraplegia=32, tetraplegia=41; Level	1. There was a significant difference in the number of years postinjury between the groups (p<0.001). Both intenders and nonintenders were injured longer ago than actors. 2. There was a significant difference in the highest level of education obtained between groups (p=0.004). A greater percentage of

	of severity: complete=19, incomplete=32. *Nonintenders (n=58):* Mean age: 46.18±12.15yr; Mean time since injury: 17.02±9.75yr; Gender: males=42, females=16; Level of injury: paraplegia=20, tetraplegia=38; Level of severity: complete=13, incomplete=22. **No Intervention:** Individuals completed a questionnaire that assessed the following Health Action Process Approach (HAPA) constructs: leisure time physical activity (LTPA) outcome expectancies, self-efficacy, intentions, planning, and action control. **Outcome Measures:** Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI).	actors completed a postsecondary education as compared with intenders and nonintenders. 3. Actors had significantly more min/day of moderate and heavy intensity LTPA than intenders and nonintenders (p<0.001). 4. For all the measures, actors scored significantly higher than intenders who scored significantly higher than nonintenders (p<0.001).
Kroll et al. (2012) UK Observational N=612	**Population:** Mean age: 48.5yr; Gender: males=386, females=226; Paraplegia=300; Complete SCI=356; Mean time since injury: 15.88yr. **No Intervention:** Participants completed mail-in surveys over 2yr examining exercise self-efficacy and exercise behaviour. **Outcome Measures:** Exercise frequency and intensity, Exercise Self-Efficacy Scale.	1. Self-efficacy beliefs were significantly related to frequency and intensity of resistance training (R^2 change=0.08 and 0.03, respectively; P<0.01 for all) and aerobic training (R^2 change = 0.07 and 0.05, respectively; P<0.01 for all). 2. Participants engaged in aerobic exercise, on average, 2.4±2.3d/wk and resistance training 2.15±2.14d/wk. 3. Participants, on average, rated their aerobic and resistance training intensity to be moderate. 4. For aerobic exercise frequency, leg use was positively associated and wheelchair use was negatively associated with exercise frequency. 5. For aerobic exercise frequency, no demographic or clinical variables were significant predictors. 6. No clinical or demographic variables contributed significantly to the prediction of resistance training intensity. Only sex demonstrated a significant association with resistance training intensity (men had higher frequency).
Perrier et al. (2012) Canada Observational	**Population:** Mean age: 47.1yr; Gender: males=531, females=164; Injury: C1-C4 ASIA A-C=75, C5-C8 ASIA A-C =184, T1-	1. On average, 28±34min per day was spent in moderate-to-heavy intensity LTPA, 22.7±28.1 min per

N=695	S5 ASIA A-C =255, ASIA D=172; Mean time since injury: 15.3yr. **No Intervention:** Participants completed a questionnaire regarding seasonal variation in total moderate-to-vigorous leisure time physical activity (LTPA), exercise and sport. **Outcome Measures:** Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI).	day was spent in exercise and 46.5±46.6 min per day in sport. 2. Season did not predict whether participants engaged in moderate-to-vigorous LTPA. 3. Season did not predict participation in sport or exercise. 4. Years post injury was the only variable that predicted exercise participation. Those injured more recently were more likely to exercise. 5. Participants who were younger were more likely to be active at any sport. 6. In the active sub-cohort, during the winter they reported engaging in less moderate to vigorous LTPA than those who were interviewed in summer. This pattern was observed for exercise as well.
Phang et al. (2012) Canada Observational N=54	**Population:** Mean age: 47.7yr; Gender: males=43, females=11; Level of injury: Paraplegia=41, tetraplegia=13; Level of severity: Complete=27, Incomplete=27. **No Intervention:** Participants completed a questionnaire and a wheelchair skills test. **Outcome Measures:** Wheelchair skills Test V4.1 for manual wheelchair users, Wheelchair Use Confidence Scale, Barriers to leisure-time physical activity, Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI).	1. A significant positive relationship was shown between wheelchair skills and leisure time physical activity ($p<0.05$). 2. Participants who were more skilled at using their manual wheelchairs reported more min/d of moderate-heavy leisure time physical activity. 3. There was a positive relationship between wheelchair skills and wheel-chair use self-efficacy ($p<0.05$). 4. Wheelchair use self-efficacy was not significantly associated with leisure time physical activity. 5. Wheelchair-use self-efficacy does not mediate the skills leisure time physical activity relationship.
Martin Ginis et al. (2011) Canada Observational N=160	**Population:** Mean age: 47.4±12.9yr; Mean time since injury: 16.2±10.1yr; Gender: males=118, females=42; Level of injury: tetraplegia=59%; Level of severity: incomplete=63%. **No Intervention:** Individuals completed a questionnaire that assessed the following Social Cognitive Theory variables: social support, task self-efficacy, self-regulatory efficacy, self-regulation,	1. Self-regulation had significant direct effects on physical activity ($p<0.05$). 2. Self-regulatory efficacy had significant indirect effects on physical activity ($p<0.05$). 3. Higher self-regulatory efficacy had significant effects on outcome expectations and use of self-regulation strategies ($p<0.05$).

	outcome expectations, and leisure time physical activity. **Outcome Measures:** Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI).	4. Self-regulatory efficacy had nonsignificant direct effects on physical activity (p>0.05). 5. Task self-efficacy did not have significant total nor indirect effects on physical activity (p>0.05). 6. Outcome expectations had nonsignificant total effects (p>0.05) on physical activity, but significant indirect effects (p<0.05). 7. Social support had nonsignificant total and indirect effects on physical activity (p>0.05).
de Groot et al. (2011) Observational Netherlands N=109	**Population:** Gender: males=79, females=30; Mean age=40.4yr; Level of injury: tetraplegia=29, complete lesion=78; Severity of injury: AIS A-D; Mean time since injury=708 days. **No Intervention:** Participants completed questionnaires assessing wheelchair satisfaction, level of physical activity, time spent on eight vocational and leisure activities, and health status. **Outcome Measures:** Dutch version of the Quebec user evaluation of satisfaction with assistive technology (D-QUEST), physical activity scale for individuals with a physical disability (PASIPD), Uretch activity list (UAL), mobility range and social behavior subscales of the SIP68 (SIPSOC).	1. High level of satisfaction was reported with wheelchair related aspects (>80%). 2. Participants were less satisfied with the service-related aspects. 3. Those with an incomplete lesion were slightly more satisfied with wheelchair related aspects (p=0.02) and service-related aspects (p=0.05) than those with complete lesion. 4. Higher satisfaction regarding wheelchair dimensions and a higher overall satisfaction were related to a more active lifestyle.
Martin Ginis, Latimer, et al. (2010) Canada Cross-Sectional N=695	**Population:** Mean age:47.1±13.5yr; Gender: males=531, females=164; Mean time post-injury: 15.3±11.1yr **No Intervention:** Data on physical activity and demographic/injury-related characteristics of SCI patients were collected through telephone interviews. **Outcome Measures:** Physical Activity Recall Assessment for Persons with Spinal Cord Injury (PARA-SCI).	1. Respondents reported a mean of 27.14±49.36 minutes of LTPA a day. 2. 50.1% of participants reported no LTPA whatsoever. 3. LTPA decreased as age and years post-injury increased. 4. Men were more active than women. 5. Manual wheelchair users were more active than power wheelchair users and persons using gait aids. 6. Participants with tetraplegia with C1–C4 and C5–C8, AIS grade A–C level injuries were significantly less active than participants with AIS grade D injuries and participants

		with paraplegia with AIS grade A to C injuries. 7. Highest amounts of daily LTPA (≥21min/d) were associated with manual wheelchair use and T1 to S5, AIS grade A to C injury. 8. Moderate LTPA (1–20min/day) was most associated with being female, 5 to 10 years post injury, and 21 to 33.8 years of age. 9. Inactivity (0min/d) was most associated with being male, greater than or equal to 11 years post injury, and greater than or equal to 33.8 years of age.
Arbour-Nicitopoulos et al. (2009) Canada Observational N=574	**Population:** Mean age: 46.89yr; Gender: males=448, females=126; Level of injury: tetraplegia=298, miscellaneous= 276; Level of severity: AIS B-D=344. **No Intervention:** Participants completed a questionnaire assessing aspects of neighborhood perceptions, and leisure time physical activity. **Outcome Measures:** Affective attitudes, instrumental attitudes, subjective norm, self-efficacy, sidewalks, esthetics: Neighborhood Environment Walkability Scale (NEWS), intentions, Leisure-time physical activity: Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI).	1. Theory of planned behavior constructs explained 57% of the variance in leisure time physical activity intentions and 12% of variance in behavior. 2. Variance in intentions increased when neighborhood variables were included within the model. 3. Esthetics exhibited significant positive relationships with theory of planned behavior variables ($p<0.01$).
Arbour et al. (2009) Canada Observational N=50	**Population:** Mean age: 43.5±12.7yr; Gender: males=35, females=15; Mean time post-injury: 13.8±10.4yr; Severity of injury: complete (15), incomplete (35); Wheelchair users: 52% manual **No Intervention:** Questionnaire **Outcome Measures:** Perceived proximity to a fitness center compared to time spent participating in leisure time physical activity	1. There was no significant association between leisure time physical activity and perceived proximity to a fitness center ($p<0.1$).
Van den Berg-Emons et al. (2008) The Netherlands Observational $N_{Initial}$=36, N_{Final}=16	**Population:** T1: Mean age: 42.1yr; Gender: males=28, females=8. T5 (n=16): Mean age: 42.2yr; Gender: males=14, females=2. **No Intervention:** Participants' physical activity level was monitored 2 consecutive weekdays every	1. Physical activity level increased significantly between T1 and T3 ($p<0.01$). Duration of dynamic activities increased by 41% (20min per 24hr; $p<0.001$) and average body motility by 19% ($p=0.008$).

	assessment period using an activity monitor. Data was collected at the start of inpatient rehabilitation (T1), 3 months later (T2), at discharge from inpatient rehabilitation (T3), and 2 months (T4) and 1 year post discharge (T5). **Outcome Measures:** Physical activity level based on accelerometry-based activity monitor.	2. Duration of dynamic activities significantly decreased from T3 to T4 (33%, p<0.001). 3. Age was significantly related to average body motility; an increase in 1yr was associated with a decrease of 7.8-10-5g average body motility. 4. Sex and completeness of lesion were not significantly related with physical activity level. 5. Those with paraplegia and with an incomplete lesion showed significantly more improvement in the duration of dynamic activities in the year after discharge than did those with tetraplegia and with a complete lesion, respectively. 6. At T5 duration of dynamic activities was 49 minutes per day. No one had wheelchair driving periods that lasted more than 10 minutes.
O'Neill et al. (2004) UK Observational N=33	**Population:** SCI=27, Guillain-Barre Syndrome=6. Gender: males=27, females=6. **No Intervention:** A telephone survey was completed capturing patients' perception of the effect of sport on rehabilitation. **Outcome Measures:** Sports participation.	1. 45.5% of participants previously participated in regular sporting activity. 2. During inpatient admission, at least one sport was tried by 72.7% of participants (bowling, archery, swimming, table tennis, basketball and darts). 3. 14 participants reported regular sporting activity post discharge. 4. Those who regularly exercised were mostly male, aged 16-35yr, had exercised previously. 5. Cardiovascular training was the most popular exercise activity (training at a gym, n=6; swimming, n=3; bowling, n=2). 6. The general benefit of sporting activity was recognized by 78.8% and the rehabilitation benefit by 69.7%. 7. Self-reported benefits from participants (n=26) included increases in fitness, quality of life, confidence and social contact. 8. Two top reasons for not exercising were poor accessibility (n=5) and not interested in sports (n=5).

Manns and Chad (1999) Canada Observational N=38	**Population:** Mean Age=30.1±9.8yr; Gender: Males=20, Females=3; Level of Injury: Quadriplegic=17, Paraplegic=21; Severity of Injury= complete; Time Since Injury=2-30yr. **No Intervention:** Not applicable. Cross sectional analysis to determine the relationships among fitness, physical activity, subjective quality of life and handicap in individuals with SCI. **Outcome Measures:** Fitness level, leisure time exercise questionnaire, Quality of Life Profile: Physical and Sensory Disabilities Version, Craig Handicap Assessment Reporting Technique.	1. Physical activity was significantly correlated with level of impairment in individuals with quadriplegia or paraplegia ($p<0.05$). 2. Scores for physical independence, mobility and occupation were significantly correlated with physical activity in individuals with quadriplegia ($p<0.05$). 3. There was no correlation between subjective quality of life scores and fitness/physical activity in individuals with paraplegia or quadriplegia ($p>0.05$). 4. More active individuals were younger and has shorter durations of injury, although, only the difference in age was significant ($p<0.05$).
Foreman et al. (1997) Australia Observational N=121	**Population:** *Sport participants (n=54):* Mean age: 31.93±8.23yr; Mean age at injury: 21.02±7.09yr; Gender: males=49, females=5; Level of injury: C=21. *Nonparticipants (n=67):* Mean age: 38.34±9.25yr; Mean age at injury: 25.02±9.40yr; Gender: males=53, females=14; Level of injury: C=45. **No Intervention:** Individuals completed a set of questionnaires including requests for demographic information and assessments of depression and anxiety. **Outcome Measures:** Centre for Epidemiological Studies Depression Scale, State Tait Anxiety Inventory.	1. There were significant differences in age, age at injury, level of lesion, and income between the groups ($p<0.05$). 2. No significant differences were found for depression between the groups ($p=0.099$). 3. Nonparticipants had a significantly higher score in trait anxiety than sport participants ($p=0.048$).

Table 3. Studies Describing Barriers and Facilitators to Physical Activity Participation Among Persons with SCI

Author Year Country Research Design Score Total Sample Size	Methods	Outcome
de Groot et al. (2020) Netherlands Observational N=96	**Population:** Gender: males=72, females=24; Mean age=47.8yr; Injury: SCI=57, amputation=14, spina bifida=2, other=19; Mean time since injury=13.2yr. **No Intervention:** Participants completed a survey which concerned the benefits of participating in the HandbikeBattle event, current sport participation, and experienced barriers and facilitators regarding current sport participation. **Outcome Measures:** Experienced benefits/losses (fitness, health, handcycling, performance activities in daily life, personal development), exercise and sports participation (average hr per week during last 3mo), experienced barriers and facilitators (personal barriers, environmental barriers, personal facilitators, environmental facilitators).	1. Reported benefits of the HandbikeBattle included fitness level (90%), personal development (81%), daily life activities (66%), and health (64%). 2. The median current sport was 5.0hr/wk. 3. Personal barriers most frequently reported were time (31%), less able to practice sport due to the disability (17%), and pain complaints (15%). 4. Most frequently reported environmental barriers were transport to sport accommodation takes a lot of time (19%), and not enough fellow athletes (16%). 5. Those who participated less in sports indicated more personal (p=0.004) and environmental barriers (p=0.02), with the largest differences in barriers 'less able to practice sport due to the disability', 'not enough fellow athletes', and 'no suitable sport facilities in my area'.
Amberkar et al (2019) India Observational N=102	**Population:** Mean age=40.41yr; Gender: males=88, females=14; Level of injury: C1-T1=10, T2-L5=92; Level of severity=complete Mean time since injury=13.39yr; Sports Participants (SCI; n=61): males=56, females=5 **No Intervention:** Not applicable. Interview survey data from four paraplegic rehabilitation centers in Mumbai to assess sports participation among people with SCI to understand	1. Sports participation was 60% among SCI participants in the study, all rehabilitation centers either promoted or made sports participation mandatory, probable reason for high rates. 2. Popular sports: basketball 20%m throwball 16%, cricket 14%, and wheelchair racing 10%. 3. Top facilitators in sport participation were financial security, family support, institutional support i.e., training facilities. 4. Barriers were lack of motivation, low confidence, poor fitness level.

	barriers and facilitators. **Outcome Measures:** Sports participation, facilitators and barriers	
Roopchand-Martin et al. (2018) Jamaica Observational N=48	**Population:** Mean age: 35.4yr; Gender: males=40, females=8; Injury: complete=28, incomplete=20; Mean time since injury: 43.6mo. **No Intervention:** Participants completed questionnaires via a phone interview pertaining to barriers to exercise and development of secondary health complications. **Outcome Measures:** The Physical Activity and Disability Scale, Spinal Cord Injury Secondary Conditions Scale and the Barriers to Exercise and Disability Scale.	1. 25% of participants reported engaging in leisure time physical activity. 2. 60.4% of participants reported exercising but only 12.2% were engaged at levels that would result in health benefits. 3. Exercise behavior was similar for those with paraplegia and quadriplegia. 4. The main barriers to exercise were cost of transportation (75%) and not knowing of a fitness center to exercise (58.3%). 5. Most participants had not experienced much secondary conditions in the past three months; however, muscle spasm (31.25%), chronic pain (20.83%) and joint and muscle pain (18.75%) were the more common.
Mat Rosly et al. (2018) Malaysia Observational N=70	**Population:** Mean age: 39yr; Gender: males=49, females=21; Level of injury: paraplegia=58, tetraplegia=12; Level of severity: AIS A=28, AIS B=6, AIS C=13, AIS D=23; Mean time since injury: 9.6yr. **No Intervention:** Questionnaires given to individuals attending outpatient SCI rehabilitation programs examining leisure time physical activity (LTPA) and barriers to exercise. **Outcome Measures:** Abbreviated Physical Activity Scale for Individuals with Physical Disabilities, Barriers to Exercise Scale.	1. 73% of participants did not engage in any form of moderate or vigorous LTPA. 2. The top three barriers to LTPA were costly exercise equipment (54%), pain while exercising (37%) and no access to facilities (36%). 3. No significant differences between moderate-vigorous LTPA participation and non-participation in type of neurological classification or time since injury. 4. The only significant predictors of a higher likelihood of not participating in moderate-vigorous LTPA were age, ethnicity, indicating that transportation was a problem and indicating that health concerns were an issue.
Hwang et al. (2016) USA Observational N=85	**Population:** Age: 18-34yr=26, 35-54yr=45, 55+=14; Gender: males=56, females=29; Level of injury: cervical=43, other=42; Type of injury: complete=36, incomplete=49; Time since injury: 1-5yr=37, 6-10yr=15, 11+yr=33. **No Intervention:** Survey that investigated personal, environmental, and activity barriers to participation in	1. The three most endorsed (agree or strongly agree) personal barriers were financial resources (53%), not prescheduling physical activities for the week (53%) and pain/discomfort (49%). 2. The three most endorsed (agree or strongly agree) environmental barriers were access to specialized SCI facilities/activities (60%), lack of environmental resources for SCI (54%) and lack of trained staff at facilities (49%).

	leisure time physical activities. The web-based survey was developed for this study. **Outcome Measures:** Barriers to participation in leisure time physical activities.	3. The three most endorsed (agree or strongly agree) activity barriers were lack of adaptive equipment (74%), lack of skills (67%) and terrain I cannot access (52%). 4. Personal barriers had a significant high negative correlation with levels of physical activity ($p<0.0001$). 5. Environmental barriers had a significant moderate negative correlation with physical activity ($p<0.0001$). 6. Activity barriers had a significant low negative correlation with physical activity ($p=0.001$). 7. Participants who were unemployed or unable to work and those with lower incomes perceived more barriers to leisure time physical activities than those who were working or had potential for being employed and those with higher incomes, respectively.
Cowan et al. (2013) USA Observational N=180	**Population:** *Exercisers (n=115):* Gender: males=72, females=43; Mean age=46yr; Level of injury: paraplegia=47, tetraplegia=68; Level of severity: AIS A-D; Mean time since injury=13yr. *Non exercisers (n=65):* Gender: males=40, females=25; Mean age=45yr; Level of injury: paraplegia=31, tetraplegia=34; Level of severity: AIS A-D; Mean time since injury=15yr. **No Intervention:** Participants completed a questionnaire which concerned demographics and current health, independence level, exercise. **Outcome Measures:** Demographics and current health, independence level, exercise: modified version of B-PED.	1. No differences between exercisers and non-exercisers for age, gender, injury level, injury duration, education level, employment status, or marital status. 2. The five most prevalent barriers were lack of energy, lack of motivation, lack of time, not knowing where to exercise and cost of the program, and were not associated with participation status. 3. The total number of perceived barriers tended to be higher among non-exercisers versus exercisers. 4. Identifying too lazy, too difficult, or no interest as a barrier decreased likelihood of being an exerciser by 86%, 83%, and 71% respectively. 5. Not liking exercise decreased the likelihood of being an exerciser by 90%.
Cowan et al. (2012) USA Observational N=180	**Population:** Gender: male=113, female=67; Mean age:47yr; Injury etiology: SCI=180, cervical injury=81. **No Intervention:** All participants completed a web-based survey of personal characteristics	1. No differences discriminated exercisers and non-exercisers by gender, age, race, injury level or completeness. 2. Higher percentage of exercisers were full-time employed or married. 3. Non exercisers reported more barriers. 4. Lack of motivation was the most highly prevalent barrier.

	(including household income) and exercise barriers. **Outcome Measures:** Barriers to Physical Exercise and Disability questionnaire (B-PED), personal characteristics, household income.	5. The most impactful barrier was "too lazy to exercise" and those who reported this as a barrier were 19 times less likely to be exercising.
Kehn and Kroll (2009) USA Observational N=26	**Population:** Mean age (range): 23-74yr; Gender: males=16, females=10; Level of injury: Tetraplegia=14, Paraplegia=9; Severity of injury: complete=11, incomplete=9; Time post injury: 1-32yr. **No Intervention:** Semi-structured interview guide was developed to explore core areas such as experiences with exercise before and after injury, logistics of current exercise regimen, barriers and facilitators of exercise, perceived benefits of exercise, perceived impact of exercise on secondary conditions. Each interview lasted between 20-30min. Analysis was conducted on patients who were exercisers vs. non-exercisers. **Outcome Measures:** Patients' experiences with exercise pre/post injury, barriers and facilitators to being active and perceived health impact measured after phone interview.	1. Non-exercisers had a significantly longer duration of injury ($p<0.05$). Other demographic and injury characteristics were not significantly different between exercisers and non-exercisers. 2. Similar barriers for both groups were reported. 3. Non-exercisers reported low return on physical investment, lack of facilities, equipment cost, fear of injury and lack of personal assistance as barriers to exercise. 4. Facilitators reported by exercisers included motivation, availability of accessible facilities and personal assistants, weight management and fear of health complications.
Vissers et al. (2008) Netherlands Observational N=32	**Population:** Mean age: 45yr; Gender: males=24, females=8, Severity of injury: tetraplegia=12, paraplegia=20; Mean time post injury: 103.5mo. **No Intervention:** Semi-structured interview. **Outcome Measures:** Response to retrospective & cross-sectional questions. 10 topic areas: subject & lesion characteristics, daily physical activity, attitude towards an	1. Most important barriers: ● In current situation: store & building accessibility, physical & mental health issues. ● After discharge: emotional distress, self-care difficulty & mental health problems. ● ↑ importance of barriers after discharge vs. current situation. 2. Most important facilitators: ● In current situation: daily physical activity preparation, physical activity stimulation & social activity preparation, in rehab center.

	active lifestyle, social activities, health, quality of life, coping, care requirements, other factors.	• After discharge: social support (family, friends, society).
Kerstin et al. (2006) Sweden Qualitative N=16	**Population:** Mean age: 36.0±10.6yr (range 21-61); Gender: males=12, females=4; Mean time post-injury: 8.6±9.8yr (range 2-41); Severity of injury: tetraplegia (8), paraplegia (8) **No Intervention:** In-person and telephone semi-structured interviews **Outcome Measures:** Major themes relating to the factors that promote participation in physical activity	1. Cognitive and behavioral strategies: role models, creating routines and goals, recalling previous experiences and acquiring new knowledge, accepting assistance. 2. Environmental solutions: accessibility, social support, equipment and funding. 3. Motivation: gaining and maintaining independence, improving physical appearance, becoming a role model 4. being competitive, establishing a self-image as physically active, becoming part of a social network. 5. New frames of reference: learning to live with narrower physical margins.
Scelza et al. (2005) USA Observational N=72	**Population:** Mean age: 44.1yr; Gender: males=50, females=22; Severity of injury: paraplegia-complete (36%), incomplete (11%); tetraplegia - complete (19%), incomplete (17%), ambulatory (17%); Mean time post-injury= 13.1yr **No Intervention:** Cross-sectional survey **Outcome Measures:** The Barriers of Physical Exercise and Disability survey; The Perceived Stress Scale.	1. 73.6% wanted to be engaged in an exercise program and 79.2% thought it would be helpful. Despite this, only 45.8% were currently participating in an exercise program. 2. Perceived Barriers: 37.5% health problems that caused a cessation in exercise (pain & fractures; 37.5%), 22.2% injured during exercise (strains & pulled muscles), 31.9% facilities (discomfort, lack of accessibility & privacy). 3. Exercise Concerns: 54.2% lack of motivation, 41.7% lack of energy, 40.3% program cost, 36.1% lack of local exercise program knowledge, 33.3% lack of interest, 31.9% lack of time. 4. Concerns of those with Tetraplegia were greater than paraplegia: health issues cause a cessation in exercise (p=0.043), difficulty to engage in exercise (p=0.024), health issue concerns prevented exercise (p=0.035). 5. Increased levels of perceived stress were related to increased concerns (p=0.036).
Levins et al. (2004) USA Qualitative N=8	**Population:** Mean age: 42yr; Gender: males=5, females=3; Level of injury: T1-low thoracic levels; Mean time post-injury: 25.6yr. **No Intervention:** Semi-structured interviews **Outcome Measures:** Major themes relating to barriers and	1. Individual influences: loss of an able identity, redefining self; turning points 2. Societal influences: environmental and attitudinal barriers, material environment (structural, financial), societal attitudes.

	facilitators to participation in physical activity	
O'Neill et al. (2004) UK Observational N=33	**Population:** SCI=27, Guillain-Barre Syndrome=6. Gender: males=27, females=6. **No Intervention:** A telephone survey was completed capturing patients' perception of the effect of sport on rehabilitation. **Outcome Measures:** Sports participation.	1. 45.5% of participants previously participated in regular sporting activity. 2. During inpatient admission, at least one sport was tried by 72.7% of participants (bowling, archery, swimming, table tennis, basketball and darts). 3. 14 participants reported regular sporting activity post discharge. 4. Those who regularly exercised were mostly male, aged 16-35yr, had exercised previously. 5. Cardiovascular training was the most popular exercise activity (training at a gym, n=6; swimming, n=3; bowling, n=2). 6. The general benefit of sporting activity was recognized by 78.8% and the rehabilitation benefit by 69.7%. 7. Self-reported benefits from participants (n=26) included increases in fitness, quality of life, confidence and social contact. 8. Two top reasons for not exercising were poor accessibility (n=5) and not interested in sports (n=5).

Dozens of factors related to physical activity were identified in the studies synthesized in Tables 2 and 3. One way to organize these factors is to situate them within a social ecological model. Social ecological models are useful for showing the interplay between individual and broader levels of influence on health (McLeroy et al. 1988). While different social ecological models may depict slightly different levels of factors that influence health, the levels typically included in social ecological models of physical activity behaviour include:

1. Intrapersonal factors: physical and psychological characteristics of the individual;
2. Interpersonal processes and primary groups: formal and informal social networks and social support systems;
3. Institutional/Organizational factors: social institutions with organizational characteristics and rules and regulations of operation;
4. Community factors: relationships among organizations, institutions and informal networks within defined boundaries; and
5. Public policy: local, state, and national laws and policies.

Drawing on the studies conducted in samples of people living with SCI, here are the key categories of factors related to physical activity at each level:

Intrapersonal level

- Psychological factors: Negative affect and emotion, attitudes/beliefs/perceived benefits, self-perceptions; use of behaviour change strategies, personality characteristics
- Body functions and structures (e.g., level of impairment, secondary health conditions, energy, strength, fitness)
- Employment status

Interpersonal level

- Social support: From family, friends, acquaintances, peers, colleagues, neighbours and community members
- Societal attitudes toward people with SCI and the appropriateness of physical activity
- Social processes (e.g., role modeling, social integration)

Institutional level

- Knowledge held by individuals working within institutions or organizations such as rehabilitation centres and fitness centres
- SCI-specific knowledge of people working in institutions or organizations such as how to exercise with SCI or the benefits of exercise for a person with a SCI
- Rehabilitation processes such as information or counseling from rehabilitation professionals to support a person with SCI to do physical activity
- Accessibility of sport, recreation and fitness facilities
- Aspects of the physical activity programs being provided such as proximity/availability and the provision of fun, safe, enjoyable activities

Community level

- Information on how or where to be active with a SCI
- Availability of equipment, particularly adaptive/accessible equipment
- Climate/weather

Policy level

- Access to transportation and transportation services
- Financial costs to the individual for programs or equipment
- Professional staff training for service providers

Looking across *Table 2* and *Table 3*, it is evident that scientists have generated a considerable volume of information on factors associated with physical activity in people with SCI. There are several excellent reviews of these studies (Fekete & Rauch, 2012; Williams et al. 2014) as well as meta-reviews of the reviews (Martin Ginis et al. 2016; Martin Ginis et al. 2021).

For the most part, this body of literature is comprised of studies conducted in high income countries including several European countries, Canada, the United States, Australia and the UK. It is encouraging to see some newer studies on barriers and facilitators emerging from middle-income countries such as Jamaica (Roopchand-Martin et al. 2018) and India (Amberkar et al. 2019). Currently, we know very little about factors related to physical activity participation among people with SCI living in middle-income countries and we have virtually no data from low-income countries. It is likely that the barriers to physical activity are different and more profound in these countries (for instance, because of a lack of infrastructure and social services) than in middle and high-income countries.

With regard to high-income countries, there has been a call to shift attention from conducting studies that merely list or describe barriers and facilitators in these countries to generating research and policies that intervene to alleviate the barriers or leverage the facilitators (Martin Ginis et al. 2016; Martin Ginis et al. 2021). With so much information already generated, it is difficult to see the benefit of conducting further studies of barriers or facilitators in high-income countries unless these studies will directly inform a planned intervention.

3.2 Interventions to Promote Physical Activity

Given the low rates of physical activity participation, as well as the multi-level barriers and facilitators to physical activity participation, among persons with SCI, the need for effective physical activity-enhancing interventions is urgent. The physical activity intervention literature in SCI has expanded substantially in the last decade. More research groups have begun to test interventions to promote physical activity participation among persons with SCI. This section reviews physical activity intervention studies that include a physical activity-related psychosocial variable and/or a measure of physical activity participation as study outcomes.

In the general population, three types of physical activity interventions have strong evidence of effectiveness: (1) Informational interventions that focus on delivering information to change knowledge and attitudes about the benefits of and opportunities for physical activity (e.g., a community-based media campaign, informational pamphlets), (2) Behavioural interventions that focus on teaching behavioural skills to promote physical activity participation (e.g., goal-setting, planning), and (3) Environmental and policy interventions that focus on changing the physical environment, social networks, organizational norms and policies to enable physical activity participation (Kahn et al. 2002). This section reviews informational (*Table 4*) and behavioural (*Table 5*) physical activity interventions given the lack of research on environmental interventions in the SCI population.

Table 4. Interventions Using Informational-Only Strategies to Increase Physical Activity Psychosocial Correlates and/or Behaviour

Author Year Country Research Design Score Total Sample Size	Methods	Outcome
Bassett-Gunter, Martin Ginis, and Latimer-Cheung (2013)	**Population:** Age=45±12yr.; Gender: males=57, females=37, not reported=2; Level of injury: Not	Psychosocial variables: 1. Post hoc tests indicated a significant increase in disease vulnerability for

Canada RCT PEDro=9 N=96	reported; Level of severity: Not reported; Time since injury>1yr. **Intervention:** Following participant recruitment and screening, baseline measures of vulnerability, response efficacy, and intentions were electronically mailed to each participant. Once baseline measures were complete, a two-step randomization procedure was followed to test the hypotheses regarding the effects of (a) risk information on vulnerability and (b) the relative effects of gain- and loss-framed LTPA message on response efficacy, intentions, and cognitive processing. **Outcome Measures:** Vulnerability, Response Efficacy, Intention, Cognitive Processing.	the experimental condition only ($p<0.001$). 2. In the ANOVA considering response efficacy for disease risk, significant main effects for time were observed. 3. There were no significant main effects for condition or time by condition interaction effects for response efficacy. 4. In the ANOVA considering LTPA response efficacy for psychological health risk, main effects for time were superseded by a significant time by condition interaction effect. 5. Planned comparisons for each condition indicated a significantly greater increase in LTPA response efficacy for the loss-framed condition compared with the control and gain-framed conditions. 6. There was no significant difference in the magnitude of increase in LTPA response efficacy between the gain-framed and the control conditions. 7. A significant main effect for time was superseded by significant time by condition interaction effects. 8. Planned comparisons for each condition indicated a significantly greater increase in intentions for the loss-framed condition compared with the control condition and a trend toward a greater increase compared with the gain-framed condition. 9. There was no significant difference between the gain framed and control conditions. 10. Neither change in disease vulnerability ($p>0.05$) nor change in psychological health vulnerability ($p>0.05$) was a significant predictor of change in intentions. 11. Change in LTPA response efficacy for disease risk was not a significant predictor of change in intentions ($p>0.05$). 12. Change in response efficacy for psychological health risk was a

		significant and positive predictor of change in intentions (p>0.05). 13. None of the individual cognitive processing variables differed between the gain- and loss-framed conditions at the Bonferroni adjusted value of (p<0.013): total thoughts (p=0.02); favorable thoughts (p=0.04); unfavorable thoughts (p=0.23); accurate recall (p=0.07).
Foulon et al. (2013) Canada RCT PEDro=6 N=79	**Population:** Gender: male=52, female=27; Level of injury: Paraplegia=37, Tetraplegia=42; Level of severity: AIS A=40, AIS B=10, AIS C=13, AIS D=15. Motivational Experimental Group: Mean age= 44.06yr, Mean time since injury: 20.39yr. Motivational Control group: Mean age=46.93yr, Mean time since injury: 23.21yr. Volitional Experimental Group: Mean age=42.17yr, Mean time since injury: 16.85yr. Volitional Control Group: Mean age=44.61yr, Mean time post injury: 12.70yr. **Intervention:** Based on a Health Action Process Approach (HAPA) participants were categorized as being in the motivational or volitional phase of behavior change and then randomly allocated to read an experimental vignette (EV) or a control vignette (CE). The informational portrait vignettes of the EV group were tailored to their demographic characteristics and targeted social cognitions for LTPA. The CE was not tailored and was written about a man with a SCI and did not talk about physical activity. **Outcome Measures:** Risk perception, outcome expectations, Task self-efficacy, Action planning, Intentions, Coping planning, Action control, Maintenance self-efficacy, Recovery self-efficacy, Perceived similarity with vignette character.	Psychosocial variables: 1. In the motivational group, those who read the EV felt more similar to the vignette character than CV group (p<0.05) on all dimensions except age and sex. 2. In the volitional group, those in the EV group felt more similar to the character on all measured dimensions (p<0.05). 3. There were no main effects of the condition or time for any of the HAPA constructs for any of the groups. 4. There was a significant condition x time interaction for coping plans. The motivational group had a non-significant decrease in coping plans among the EV group but no change for CV group. In the volitional group, there was a non-significant increase in coping plans for the CV group but no change for EV group.

Table 5. Interventions Using Behavioural Strategies to Increase Physical Activity Psychosocial Correlates and/or Behaviour

Author Year Country Research Design Score Total Sample Size	Methods	Outcome
Chemtob et al. (2019) Canada RCT PEDro=7 $N_{Initial}$=24, N_{Final}=22	**Population:** Mean Age= 51.64 yr; Gender: Males=16, Females=6; Injury Etiology: Traumatic=13, Non-traumatic=9; Level of Injury: Paraplegia=22; Mean Time Since Injury=15.45 yr **Intervention:** Intervention Group (n=10): The intervention group received one, 1-h counselling session per wk, for 8 wk, delivered via an online video-chat platform. The counselling sessions focused on fostering the basic psychological needs and autonomous motivation, teaching behaviour change techniques, and self-regulatory strategies; Control Group (n=12): The control group received no interventions and was asked to continue with their regular routine. **Outcome Measures:** Primary outcome measures: Psychological Needs Satisfaction in Exercise Scale, Treatment Self-Regulation Questionnaire. Secondary outcome measures: Leisure-Time Physical Activity Questionnaire, total moderate to vigorous leisure time physical activity (MVPA), total leisure time physical activity (LTPA), The Life Satisfaction Questionnaire-11, Patient-Health Questionnaire-9, Patient-Perceived Participation in Daily Activities.	Psychosocial variables: 1. Compared to the control group, the intervention group reported greater autonomous motivation post intervention (Hedge's g = 0.91) 2. Large to moderate effects supporting the intervention group were found for social cognitive predictors of LTPA (Hedge's g > 0.76) post-intervention. Physical activity participation: 1. Compared to the control group the intervention group reported greater levels of LTPA post intervention (Hedge's g = 0.85).
Ma et al. (2019) Canada RCT PEDro=5 $N_{Initial}$=32, N_{Final}=28	**Population:** Gender: males=17, females=11; Level of injury: Tetraplegia=13, Paraplegia=15. ProACTIVE SCI: Mean age: 45.79yr; Mean time since injury: 14.71yr.	Psychosocial variables: 1. Significant group × time effects were found for affective outcome expectancies, intentions, moderate and heavy aerobic self-efficacy, moderate and heavy

	Controls: Mean age:45.57yr; Mean time since injury:18.14yr. **Intervention:** Participants were performing <150min of moderate to vigorous PA per week and randomized to either ProACTIVE SCI or a wait list control group. ProACTIVE SCI was a 1h introductory session and 8 weekly 10-15min behavioural PA coaching sessions. Resistance bands were provided. A wrist accelerometer was worn on the non-dominant wrist. **Outcome Measures:** Accelerometer-measured Physical Activity, Leisure Time Physical Activity Questionnaire for People with SCI (LTPAQ), Peak Oxygen Uptake test, Health Action Process Approach (HAPA) constructs.	strength self-efficacy, action planning, monitoring, social support, and knowledge in favor of the intervention condition. Physical activity participation: 1. There was a significant large group x time effect of the intervention on LTPAQ total PA and moderate to vigorous physical activity. 2. The intervention group, on average, had almost three times more total physical activity and five times more moderate to vigorous physical activity than controls post-intervention. 3. Self-reported physical activity increased significantly over time within the intervention group (between baseline and week 4, 7, postintervention and follow-up).
Arbour-Nicitopoulos et al. (2017) Canada RCT PEDro=9 N=90	**Population:** *Guidelines* Age=48.79±10.59yr.; Gender: males=29, females=13; Level of injury: paraplegia=17, quadriplegia=25; Level of severity: Not reported; Time since injury=17.88±11.62yr. *ToolKit* Age=47.11±10.23yr.; Gender: males=31, females=4; Level of injury: paraplegia=17, quadriplegia=18; Level of severity: Not reported; Time since injury=17.06±12.56yr. **Intervention:** Participants were randomized to view the SCI Get Fit Toolkit or the Physical Activity Guidelines for adults with SCI (PAG-SCI) and outcome measures were taken at baseline, 24 hours post-baseline, 1-week post-intervention, and 1-month post-intervention. **Outcome Measures:** Intentions, outcome expectancies, task self-efficacy, barrier self-efficacy, action planning, MVPA behaviour.	Psychosocial variables: 1. At 24-hour post-baseline, no condition effects on residual change of intentions, task self-efficacy, or barrier self-efficacy were evident. 2. Post hoc analysis revealed near significant positive changes in intentions (p=0.06) and barrier self-efficacy (p=0.05) at 24 hours post-baseline. 3. Post hoc analysis showed significant change in outcome expectancies (p=0.02) at 24 hours post-baseline. 4. No time effects were shown for task self-efficacy at 24 hours post-baseline. 5. At 1-week post-intervention, no condition effects were found for residual change in intentions, task self-efficacy, barrier self-efficacy or action planning. 6. At 1-month post-intervention, no condition effects were found for residual change in intentions, task self-efficacy, barrier self-efficacy or action planning.

		7. Post hoc analysis reported a decrease in task self-efficacy at 1-week (p=0.03) and 1-month (p<0.001) post-intervention. 8. No other significant changes were found via post-hoc analysis. Physical activity participation: 1. 1-week post-intervention, participants in the toolkit condition were 3.54 times more likely to participate in at least one bout of 20 min of MVPA compared to participants in the guidelines condition. 2. At 1-month post-intervention, participants in the toolkit condition were 1.82 times more likely to engage in at least 20 min of MVPA in the past week compared to participants in the guidelines condition.
Kooijmans et al. (2017) Netherlands RCT PEDro=6 N=64	**Population:** Gender: males=45, females=19; Level of injury: tetraplegia=22; Level of severity: Complete=50. Intervention group: Mean age: 48yr; Mean time since injury: 21yr. Control group: Mean age: 49yr; Mean time since injury: 23yr. **Intervention:** Participants were randomized to either a 16wk self-management intervention (HABITS) or the control group that received information about an active lifestyle. The HABITS intervention targeted optimizing intentions toward a healthier lifestyle and improved perceived behavioral control. The intervention group received 1 home visit, 5 individual and 5 group sessions. Assessments were done pre and post intervention and at 42wk. **Outcome Measures:** Amount of self-propelled wheelchair driving, Physical Activity Scale for Individuals with Physical Disabilities, SCI exercise self-efficacy scale, Utrecht Proactive Coping Competence scale, University of Rhode Island Continuous measure, Exercise Decisional Balance.	Psychosocial variables: 1. No overall intervention effect or between-group differences were shown for perceived behavioral control. Physical activity participation: 1. No overall intervention effects were found on the amount of self-propelled wheelchair driving and self-reported physical activity.
Nooijen et al. (2016)	**Population:** Mean age: 44yr; Gender: males=33, females=12; Level of injury:	Psychosocial variables:

Netherlands RCT PEDro=6 N=45	tetraplegia=13; Level of severity: complete=24; Mean time since injury: intervention=139d, control=161d. **Intervention:** Participants were stratified based on lesion level and completeness and then randomized to either the intervention or control group. All participants completed a structured handcycle training program during their last 8wk of inpatient rehabilitation. The intervention group also had a behavioral component which was 13 individual face-to-face sessions with a coach to promote a physically active lifestyle. **Outcome Measures:** Fatigue Severity Scale, The Center for Epidemiological Studies Depression Scale, Pain Intensity Score, Illness Cognition Questionnaire, Exercise Self-Efficacy Scale, Utrecht Proactive Coping Competence Scale, Social Support for Exercise Behavior Scale, Objectively Measured Wheeled Physical Activity.	1. There was no direct significant intervention effect for fatigue, exercise self-efficacy, proactive coping, social support family, or social support friends. 2. The intervention effect on physical activity was mediated separately by >10% by pain, disability, helplessness, exercise self-efficacy and proactive coping.
Thomas et al. (2011) USA RCT PEDro=5 N=21	**Population:** Mean age: 43.6yr; Gender: male=10, female=11; Level of injury: C1-C7=9, T1-T5=6, Below T5=6. Mean time since injury: 12.3yr. **Intervention:** Participants had not engaged in an exercise program in the previous 6 months. Participants kept a daily activity log for three months. After the first 3 months, participants were randomized to the basic intervention (BI) group or the enhanced intervention (EI) group (3 months). The BI group's video contained education on benefits of physical activity and specific exercises that could be done. The same was given to the EI group in addition to individualized instruction in an in-home physical activity program, provided exercise supplies and given telephone check-ins periodically. Participants were evaluated at baseline, 3mo, 6mo (post intervention) and 9mo follow-up. **Outcome Measures:** Transtheoretical model of health behavior change (TTM) questionnaire, Borg Rating of	Physical activity participation: 1. There were no significant between group differences in terms of mean self-reported days per week with a minimum of 10 minutes of continuous moderate physical activity at any assessment point. 2. The number of physical activity minutes significantly increased in the BI group at 3 months ($p<0.05$), 6 months ($p<0.01$) and 9 months ($p<0.05$) compared to baseline. 3. The number of physical activity minutes in the EI group increased significantly at 6 months and 9 months compared to baseline ($p<0.05$). 4. No significant between group differences were found in terms of number of physical activity minutes.

	Perceived Exertion Scale, self-reported physical activity log.	
Wise et al. (2009) USA RCT PEDro=7 N=21	**Population:** *Basic* ***Intervention:*** Age=43.3±13.1yr.; Gender: males=5, females=6; Level of injury: C1-C7=5, T1-T5=2, Below T5=4; Level of severity: Not reported; Time since injury=11.6±8.5yr. *Enhanced* ***Intervention:*** Age=44.0±16.1yr.; Gender: males=5, females=5; Level of injury: C1-C7=4, T1-T5=4, Below T5=2; Level of severity: Not reported; Time since injury=13.0±10.3yr. **Intervention:** Participants were instructed by a physical therapist to document their daily physical activity over 3 months from time point 1 (T1) to T2. At T2 participants were randomized to a Basic Intervention group (BIG; n=11) in which they received a brochure and a DVD/videotape explaining the benefits of physical activity and giving specific examples of appropriate exercises for individuals with SCI, or an Enhanced Intervention group (EIG; n=10) in which they received the same brochure and DVD given to participants in the BIG, as well as, individualized instruction in an in-home physical activity program, along with a varied array of exercise supplies. **Outcome Measures:** Range of Motion (ROM), Upper Extremity Manual Muscle Testing (UE MMT), Self-Reported Physical Activity (min/wk).	Physical activity participation: 1. Improvement in physical activity was significant at T2 (p<0.05), T3 (p<0.01), and T4 (p<0.05) when compared to baseline value for BIG. 2. Improvement in EIG physical activity was significant at T3 and T4 (p<0.05). 3. Improvement in physical activity was not significant for between group comparison (p>0.05). 4. When the groups were combined, the degree of improvement in physical activity was significant for each assessment visit (T2, p<0.01; T3, p<0.001; T4, p<0.01) when compared to baseline value.
Arbour-Nicitopoulos et al. (2009) Canada RCT PEDRo=7 $N_{Initial}$=44, N_{Final}=38	**Population:** ACP condition group: Mean age: 49.00±12.93yr; Mean time post-injury: 18.01±14.16yr; Gender: males=15, females=7; APO condition group: Mean age: 50.41±12.76yr; Mean time post-injury: 11.75±9.82yr; Gender: males=15, females=7. **Intervention:** Participants were randomly divided into either an action planning group (APO) or action coping planning (ACP) group. Informational, instructional and other materials to assist with exercise were provided to participants prior to	Psychosocial variables: 1. No difference was found in the frequency with which participants altered their original action plans over the 10-week period between ACP and APO condition groups. 2. Participants in the APO condition did not spontaneously form coping plans over the 10 weeks. 3. LTPA intentions decreased for both conditions over weeks 2 to

	initiating a 10wk program. Both groups were facilitated in completing an action plan and the ACP group also developed a coping plan intended to assist in overcoming potential barriers. **Outcome Measures:** Leisure time physical activity (LTPA) participation as measured by a short version of the PARA-SCI, Intentions (2 Likert type questions), Coping self-efficacy, General barriers self-efficacy, Facility barriers self-efficacy, Scheduling self-efficacy, Health-related break from LTPA. Most measures were collected pre and post 10wk intervention as well as mid-point (5wk).	10. No significant main effect for condition or time and condition interaction was found. 4. A significant medium-sized effect for time for general barriers self-efficacy was observed. 5. Confidence to schedule moderate to heavy LTPA decreased for both groups over weeks1 to 10. However, significant medium-large sized effects for condition were found for all 3 types of coping self-efficacy. 6. Participants in the ACP condition group had greater confidence to schedule and overcome LTPA-related barriers compared to the APO condition group. 7. The APO condition group had greater confidence to overcome facility-related barriers than did those in the ACP condition. 8. For the intervention– coping self-efficacy relationship, the ACP condition group had greater scheduling and barrier self-efficacy, and lower facility related barriers than the APO condition group. Physical activity participation: 1. LTPA participation was significantly greater at weeks 5 and 10 for the ACP condition in comparison with the APO condition group. The main effect for time or the time and condition interaction was not significant.
Latimer et al. (2006) Canada RCT PEDro=4 $N_{Initial}$=54, N_{Final}=37	**Population:** Chronic SCI; Mean age: 40.61yr; Gender: males=16, females=21; Level of injury: paraplegia (35), tetraplegia (19); Mean time post-injury: 19.34yr **Intervention:** Intervention group: Subjects and researchers created implementation intentions over the telephone, for 30min of physical activity 3d/wk, for 4wk. A 4wk calendar and daily log book was emailed to the subject. After 4wk, implementation intentions and calendars were updated for	Psychosocial variables: 1. Scheduling self-efficacy: ↑ at week 5 when implementation intentions were utilized (p=0.04). 2. PBC and barrier self-efficacy did not differ between groups. Physical activity participation: 1. Minutes of daily physical activity were higher when implementation intentions were utilized (p=0.04). 2. The overall number of days subjects participated in ≥ 30 min

	subsequent 4 wks. Control group: Subjects were advised by an interventionist to engage in 30 min of physical activity 3d/wk, for 4 wks. Subjects verbally recited activities they would perform, and these were put into a calendar and emailed with a daily log book. After 4wk, verbal recitation occurred again and a new calendar and daily log was received for a subsequent 4wk. **Outcome Measures:** Intentions- 2 statements used: 1) "I will try to do at least 30 min of moderate to heavy physical activity 3d/wk over the next 4 wks" (1= definitely false; 7= definitely true); 2) "I intend to do at least 30 min of moderate to heavy physical activity 3d/wk in the forthcoming month (1=extremely unlikely; 7=extremely likely); Physical Activity: Physical Activity Recall Assessment for Individuals with Spinal Cord Injury (PARA-SCI); Perceptions of control (perceived behavioural control, PBC; scheduling self-efficacy; barrier self-efficacy).	of physical activity was not affected by intention implementation. 3. The intentions-behavior relationship was significantly stronger in the intervention group (p=0.03), as compared to the control group.
Zemper et al. (2003) USA RCT PEDro=4 $N_{Initial}$=67, N_{Final}=43	**Population:** SCI: Mean age: 47yr (range 22-80); Gender: males=30, females=13; Level of injury: paraplegia (18), tetraplegia (17), ambulatory (8); Mean time post-injury: 14yr (range 1-49) **Intervention:** Intervention group: 6 - 4hr workshop sessions over 3mo, which included lifestyle management, physical activity, nutrition, preventing secondary conditions, 3 individual coaching sessions, and 2 follow-up calls within 4 mos. after workshop. Control group: no intervention. **Outcome Measures:** Health Promoting Lifestyle Profile II; Secondary Conditions Scale; Self-rated Abilities for Health Practices scale (SAHP); Perceived Stress Scale; Physical activities with disabilities (PADS); Arm crank ergometer testing; neurologic exam; Body Mass Index (BMI); all at baseline and post-study.	Psychosocial variables: 1. When compared to control group, the intervention group showed statistically significant improvements in the following: ● Health practice abilities (SAHP, p<0.05); ● Health promoting lifestyle (HPLP- II, p<0.001); ● ↑ of stress management techniques, ↓ perceived stress (HPLP-II subscale, p=0.001). Physical activity participation: 1. Physical Activity (HPLP-II): ↑ physical activity and improved physical fitness (p=0.001); however, no improvement on the PADs or physical fitness measures.
Jeske et al. (2020)	**Population:** Median age: 39yr; Gender: males=8, females=1; Level of injury:	Psychosocial variables:

Canada Pre-Post N=9	paraplegia=2, tetraplegia=7; Median time since injury: 18yr. **Intervention:** Videoconference intervention using group-mediated cognitive behavioral counseling focused on adding 20min of LTPA per week. Intervention was four, 60-min, weekly skype sessions led by a facilitator trained in behavior change techniques and group mediation. Session themes included: group unity, self-monitoring, goal setting and problem solving. An online survey was conducted at baseline, post-sessions and 24hr post-intervention. **Outcome Measures:** Leisure Time Physical Activity Questionnaire for Adults with SCI.	1. 78% of participants (n=7) either increased or maintained their level of intention to add an additional 20min of moderate to heavy leisure time physical activity per week. Physical activity participation: 1. 44% (n=4) added at least one, 20min bout of mild or moderate-heavy intensity leisure time physical activity during the week following the intervention.
Hiremath et al. (2019) USA Observational $N_{Initial}$=20, N_{Final}=16	**Population:** Mean age: 39.4±12.8yr; Mean time since injury: 12.4±12.5yr; males=16; Level of injury: paraplegia=16, Level of severity: complete=12. **Intervention:** The first, second, and third phases of the study, each 1mo long, involved collecting baseline physical activity (PA) levels, providing near-real-time feedback on PA level (PA Feedback), and providing PA Feedback with just-in-time-adaptive intervention (JITAI), respectively. A smartwatch and a wheel rotation monitor streamed data to the smartphone. Individuals received six audio/vibration prompts once/2hr to answer questions on the smartphone. **Outcome Measures:** Leisure Time Physical Activity Questionnaire for people with SCI (LTPAQ-SCI), Fatigue Severity Scale (FSS), Wheelchair User's Shoulder Pain Index (WUSPI).	Physical activity participation: 1. Participants reported 26.0±17.8 min/day of light intensity physical activity, 17.7±13.8 min/day of moderate intensity physical activity, and 11.7±15.5 min/day of vigorous physical activity at baseline. 2. After the PA Feedback phase, participants reported 28.2±23.8 min/day of light intensity physical activity, 23.3±19.8 min/day of moderate intensity physical activity, and 13.2±17.1 min/day of vigorous physical activity. 3. After the PA Feedback with JITAI phase, participants reported 25.8±22.9 min/day of light intensity physical activity,17.5±21.6 min/day of moderate intensity physical activity, and 10.6±13.5 min/day of vigorous intensity physical activity. 4. A smaller number of participants had a considerable decrease in their light- and/or moderate-intensity PA during PA Feedback with JITAI. 5. Compared to the PA Feedback with JITAI phase a smaller number of participants were able to considerably increase their light- and/or moderate-intensity PA during the PA Feedback phase.

		6. Most of the participants indicated that they were performing a higher level of light- and/or moderate-intensity PA during the PA Feedback and PA Feedback with JITAI phases, but few participants indicated that chronic pain, being busy at work, weather, hospitalization not related to the study, and lack of accessible resources led to a decrease in PA levels.
Tomasone et al. (2018) Canada Pre-Post $N_{initial}$=46 N_{final}=25	**Population:** Age=51.46±12.36yr.; Gender: males=23, females=22, not reported=1; Level of injury: paraplegia=23, tetraplegia=21, not reported=2; Level of severity: Not reported; Time since injury=17.00±17.59yr. **Intervention:** Participants completed informational/behavioural phone call counselling sessions to explore the implementation correlates of change in leisure time physical activity (LTPA) intentions and behavior in the second phase of Get In Motion (GIM). **Outcome Measures:** LTPA Intentions, LTPA Behaviours, Counselling Session Checklist, Client Reflection.	Psychosocial variables: 1. Client's baseline intentions for engaging in aerobic, strength-training, and total LTPA were high and did not change over the course of the 6-month service (p≥0.24). Physical activity participation: 1. Significant time effects were seen for changes in time spent in strength-training and total MVPA over the 6-month period (p≤0.03). 2. No significant changes in time spent in strength-training or total MVPA were seen between 2 and 6 months (p≥0.23).
de Oliveira et al. (2016) Australia PCT N=64	**Population:** Inactive Group: Mean age: 48.9yr; Gender: males=51%, females=49%, Level of injury: C5-C8, A: 21.5%, C5-C8, B or C: 30%, T1–S4 to S5, A: 21.5%, T1–S4 to S5, B or C: 27%; Injury etiology: traumatic: 73%, non-traumatic: 27%; Mean time post injury: 9yr. Active group: Mean age=48.2yr; Gender: males=89%, females=11%; Level of injury: C5-C8, A: 11%, C5-C8, B or C: 30%, T1–S4 to S5, A: 37%, T1–S4 to S5, B or C: 22%; Injury etiology: traumatic: 93%, non-traumatic: 7%; Mean time post injury: 10yr. **Intervention:** Participants took part in the Spinal Cord Injury and Physical Activity in the Community (SCIPA Com), which involved supervised physical activity programs 2x/wk for 30-60min for 8-12wk. **Outcome Measures:** Physical Activity Recall Assessment for Individuals with	Physical activity participation: 1. Participants showed a significant improvement in leisure-time physical activity (LTPA) levels compared to baseline (P<0.001), 2. Participants showed a significant improvement in functional goal achievement compared to baseline (p<0.001). 3. Over time, LTPA participation was greater among the active than the inactive group, although LTPA levels among the inactive improved compared with baseline (p<0.05).

	Spinal Cord Injury (PARA-SCI), Patient-Specific Functional Scale (SFS), Rosenberg Self-Esteem Scale (RSS), World Health Organization Quality of Life Scale – BREF (WHOQOL-BREF)	
Arbour-Nicitopoulos et al. (2014) Canada Pre-post N=65	**Population:** Mean age: 50.42yr; Gender: male=37, female=27; Level of injury: Paraplegia=30, Tetraplegia=29; Mean time since injury: 14.46yr. **Intervention:** *Get in Motion* participants were given two elastic resistance bands, instructional guide, safety sheet and strategies for meeting LTPA goals. Participants received telephone-based counseling (10-15min) by exercise counselor trained in motivational interviewing and behavior change theory. *Get in Motion* service utilized the Health Action Process Approach (HAPA) model. Participants received calls weekly for first 2 months, bi-weekly for months 2-4 and monthly for months 4-6. **Outcome Measures:** Intentions, self-report LTPA Questionnaire for people with SCI (LTPAQ-SCI)	Psychosocial variables: 1. Clients' intentions for engaging in regular LTPA were high at baseline and were sustained through the 6-month period (p=0.44). Physical activity participation: 1. There was a non-significant increase in the percentage of clients who were regularly active at baseline compared to 4 months (p=0.13) and 6 months (p=0.09).
Pelletier et al. (2014) Canada Pre-Post N=17	**Population:** Mean age: 42.1yr; Gender: male=13, female=4; Level of injury: C3-T12; Level of severity: AIS A-C; Mean time since injury: 8.4mo. **Intervention:** Participants were categorized based on discharge program (inpatient, n=9 or outpatient, n=8) and received a referral from their PT for physical activity (PA; twice per wk). The PA could be completed as unstructured LTPA or part of a structured community program. Participants also received continuous PA counselling and support for 16wk post discharge (every 4 wk). Those who did not want to participate in counselling were monitored for adherence to referral only. **Outcome Measures:** Exercise beliefs questionnaire (outcome value, outcome expectation, scheduling self-efficacy, task self-efficacy), adherence (i.e., attendance or self-report).	Psychosocial variables: 1. No significant differences were found on any of the constructs (outcome value, outcome expectation, scheduling and task self-efficacy) measured between groups. 2. No significant correlations were found between any of the constructs and adherence rates. Physical activity participation: 1. Participants attended an average of 17.4 exercise sessions out of a possible 32 (54.4% adherence rate).

Brawley et al. (2013) Canada Pre-Post N=10	**Population:** Mean age: 57.0yr; Gender: male=5, female=5. **Intervention:** Participants were recruited from a supervised leisure time physical activity program that met twice weekly and offered strength and aerobic regimens. Participants completed a group-mediated cognitive-behavioral training intervention (9wk) for increasing self-managed leisure time physical activity (LTPA). 60 min face-to-face sessions were held weekly for 7 weeks. A structured individual telephone counselling session occurred in week 9 and assessments were done at week 10. **Outcome Measures:** Self-regulatory efficacy, Action plan agreement, modified version of LTPAQ-SCI, Likelihood of physically meaningful outcomes.	Psychosocial variables: 1. A significant increase in participants' perceived likelihood of obtaining important physical outcomes consistent with their self-managed LTPA (p=0.04). 2. Self-regulatory efficacy for scheduling and planning an extra day of self-managed LTPA in the upcoming weeks was almost at the ceiling at baseline (M = 86.20 out of a maximum of 100, SD=10.49), and remained high at the end of the intervention (M= 89.43, SD=10.23). 3. Action planning showed a marginally significant increase from pre- to post-intervention (p=0.06). Physical activity participation: 1. There was a significant increase in weekly minutes of moderate to heavy self-managed LTPA from pre to post intervention (p<0.02). 2. There was no significant difference in structured LTPA minutes.
Latimer-Cheung et al. (2013) Canada Pre-post Study 1 N=7, Study 2 N=12	**Population:** Study 1 (n=7): Mean age: 51.86yr; Gender: male=4, female=3; Level of injury: Paraplegia=6; Severity: Complete=4, Incomplete=3; Mean time since injury: 28.76yr. **Intervention:** a single, 30min counseling session using motivational interviewing principles to strengthen social cognitions associated with LTPA. Participants were assessed the next day. **Outcome Measures:** Leisure Time Physical Activity Questionnaire for People with SCI. **Population:** Study 2 (n=12): Mean age: 42.92yr; Gender: male=5, female=7; Level of injury: Paraplegia=12; Severity: Complete=7, Incomplete=5; Mean time since injury: 23.21yr. **Intervention:** A home visit by a certified personal trainer and a peer with paraplegia. Education about strength training, identified existing resources in the home that could be	Study 1 Psychosocial variables: 1. Significant medium to large sized increases in goal setting self-efficacy (d=0.72) and intention strength (d=1.01) (p<0.032) from pre to post intervention. 2. Small to medium sized effects emerged for intentions and action planning but they were not significant. Study 2 Psychosocial variables: 1. Significant medium to large sized increase for task frequency self-efficacy (d=0.52), barrier self-efficacy (d=0.87), intentions (d=0.60), and action planning (d=1.14) (p<0.28). 2. There were no significant increases in task duration self-efficacy, goal setting self-efficacy, or scheduling self-efficacy.

	used for strength training and had exercises modelled for them that they could try while the trainer reinforced participants' performance and past mastery experiences. Participants were assessed pre intervention, post intervention 1 week later and follow-up (5wk later). **Outcome Measures:** modified Leisure Time Physical Activity Questionnaire for People with SCI, social-cognitive variables (self-efficacy, intentions, action planning).	Physical activity participation: 3. Number of bouts of strength training, duration and total min per week of strength training increased significantly ($p<0.024$). 4. At follow-up, 9 of 11 participants were strength training at least twice per week.
Dolbow et al. (2012) USA Pre-Post N=17	**Population:** Mean age: 45.8±13.8yr; Gender: males=15, females=2; Level of injury: cervical=11, thoracic=6; Severity of injury: AIS A=5, AIS B=9, AIS C=3; Time since injury: 12.0±13.3yr. **Intervention:** Home-based functional electrical stimulation cycling program 40-60min sessions, 3 times/wk for 16wk. **Outcome Measures:** Exercise adherence.	Physical activity participation: 1. There was no significant decline in adherence over the study period. 2. The odds of adhering to the exercise program were greater for younger versus older participants, those without pain versus those with pain, and for those who were active versus inactive prior to the study ($p<0.05$ for all). 3. Level of injury, time since injury and history of depression had no effect on rate of adherence.
Warms et al. (2004) USA Pre-Post $N_{Initial}$=17, N_{Final}=16	**Population:** Mean age: 43.2yr; Gender: 13 males, 3 females; Mean time post-injury: 14.4yr. **Intervention:** "Be Active in Life" program: included educational materials (2 pamphlets, 2 handouts), a home visit with a nurse (90 min scripted motivational interview, goal and personal action plan establishment), and follow up calls at day 4, 7, 11 & 28 (approx. 8min each). Program lasted for 6wk, and had a final follow up 2wk post-completion. **Outcome Measures:** Physical activity (wrist-worn actigraph); Self-rated Abilities for Health Practices Scale (includes Exercise Self-efficacy subscale); Self-rated Health Scale (SRHS); Centre for Epidemiologic Studies Depression Scale (CES-D); @ baseline, 6wk completion; 2wk post-completion.	Psychosocial variables: 1. There was no significant change in self-rated abilities for health practices from pre- to post-intervention. 2. Exercise self-efficacy significantly increased from pre- to post-intervention ($p=0.05$). Physical activity participation 1. Counts/day increased in 60% of subjects, and self-reported activity increased in 69% of subjects, but both were not significant.

Discussion

Over the past decade, there has been a burgeoning amount of research exploring informational and behavioural interventions to increase leisure-time physical activity psychosocial variables and behaviour among persons with SCI. All interventions have been developed and evaluated in high-income countries including Canada, the United States, the Netherlands and Australia. Future intervention research is required to test the efficacy of physical activity-enhancing interventions for persons with SCI in low- and middle-income countries.

Recognizing the importance of offering evidence-based information about p (Williams et al. 2017), informational strategies (e.g., offering information about the benefits of physical activity or risks of physical inactivity, examples of exercises that can be performed) are sometimes used independently in interventions. Of the two interventions that used informational-only strategies, one RCT (Bassett-Gunter et al. 2013) showed positive changes, whereas one RCT (Foulon & Ginis, 2013) demonstrated no change, in physical activity-related psychosocial variables. Changes in physical activity participation were not assessed in either study.

Most intervention studies used behavioural strategies. Of the 22 studies that used behavioural strategies, six RCTs (Arbour-Nicitopoulos, Ginis, et al. 2009; Arbour-Nicitopoulos et al. 2017; Chemtob et al. 2019; Latimer et al. 2006; Ma et al. 2019; Zemper et al. 2003) and four pre-post studies (Brawley et al. 2013; Jeske et al. 2020; Latimer-Cheung et al. 2013; Warms et al. 2004) highlighted increases in physical activity-related psychosocial variables, whereas two RCTs (Kooijmans et al. 2017; Nooijen et al. 2016) and three pre-post studies (Latimer-Cheung et al. 2013; Pelletier et al. 2014; Tomasone, Arbour-Nicitopoulos, et al. 2018) demonstrated no change in physical activity-related psychosocial variables.

Eight RCTs (Arbour-Nicitopoulos, Ginis, et al. 2009; Arbour-Nicitopoulos et al. 2017; Chemtob et al. 2019; Latimer et al. 2006; Ma et al. 2019; Thomas et al. 2011; Wise et al. 2009; Zemper et al. 2003), one prospective controlled trial (De Oliveira et al. 2016), and five pre-post studies (Brawley et al. 2013; Hiremath et al. 2019; Jeske et al. 2020; Latimer-Cheung et al. 2013; Tomasone, Arbour-Nicitopoulos, et al. 2018) reported changes in physical activity participation following the intervention. One RCT (Kooijmans et al. 2017) and three pre-post studies (Arbour-Nicitopoulos et al. 2014; Dolbow et al. 2012; Warms et al. 2004) reported no change in physical activity behaviour following the intervention. Of note, four interventions combined both informational and behavioural strategies (Arbour-Nicitopoulos et al. 2017; Latimer-Cheung et al. 2013; Tomasone, Arbour-Nicitopoulos, et al. 2018; Wise et al. 2009). Also noteworthy is that behavioural strategies were implemented with varying degrees of intensity, from offering information about how to engage in behavioural strategies (Arbour-Nicitopoulos et al. 2014) to having one-on-one tailored interventionist support for engaging in behavioural strategies (Tomasone, Arbour-Nicitopoulos, et al. 2018).

The use of multiple strategies across behavioural interventions makes it challenging to tease apart the isolated impact of individual intervention strategies. However, in a review that extracted behaviour change techniques (or “active ingredients” of behavioral interventions) (Michie et al. 2013) used in physical activity interventions for persons with SCI (Tomasone, Flood, et al. 2018), the following strategies were associated with positive LTPA outcomes and can be considered in future interventions that aim to increase physical activity-related psychosocial variables and/or behaviour: goal setting (i.e., setting a level of physical activity to be achieved), problem solving (i.e., analysis of factors influencing physical activity behaviour and selecting strategies that overcome barriers and/or increase facilitators to participation), action planning (i.e., setting a detailed plan of what, when, where and how physical activity will be performed) and social support (i.e., providing non-contingent praise and/or emotional support for performance of the behaviour) (Michie et al. 2013).

The use of theory has been encouraged for SCI physical activity research (Best et al. 2017). Many of the included studies used an established theoretical framework to guide intervention content, intervention evaluation, and/or interpret findings. The included studies reported using theories and/or theoretical constructs from the Health Action Process Approach Model (Schwarzer et al. 2011), the Theory of Planned Behaviour (Ajzen, 1991), the Transtheoretical Model (Marcus & Simkin, 1994), Self-Efficacy Theory (Bandura, 2004), and Self-Determination Theory (Ryan & Deci, 2017). A theory is an abstract set of interrelated concepts, definitions and relationships that can predict or explain how certain phenomena, events or behaviour occur (Glanz & Bishop, 2010). When considering theory use, it is important to consider how theories can be used in intervention studies. Theory can be used to (1) guide the design of intervention (i.e., select intervention strategies that will target a theory's constructs); (2) explore mediators or moderators of the behaviour or effects of the intervention; or (3) offer a post hoc/retrospective explanation of study findings (i.e., theory has been introduced once the intervention is executed) (Davies et al. 2010). Studies may also vary in the degree to which theory is employed; that is, intervention studies may (1) be explicitly theory-based, wherein the intervention and evaluation of the intervention are based on a named theory, and the study offers a direct test of one or more hypotheses deduced from a named theory (i.e., to determine whether the intervention findings can be explained by the theoretical base); (2) have some conceptual basis in a theory, wherein theory is employed in the design of the intervention or evaluation, but tests of hypotheses deduced from theory are not conducted; or (3) use or examine some theoretical constructs from a theory without use of the entire theory (Davies et al. 2010). However, theory use varies in physical activity interventions for persons with SCI to date; some studies included in this module were explicitly theory-based whereas others did not use theory (or offered a poor reporting of theory). When theories are explicitly used to develop an intervention, it is more likely that important determinants of physical activity behaviour are targeted in the intervention, which should hypothetically increase intervention effectiveness (Glanz & Bishop, 2010). Future intervention research should consider the extent to which theory is used in intervention design and evaluation if we want to fully grasp the impact of theory in physical activity-enhancing interventions in the SCI community.

While it is encouraging that theory use is expanding in this field, theory use alone cannot fully account for the effectiveness and maintenance of physical activity interventions. Other intervention features, such as intervention tailoring, dose, delivery mode, and provider, can also influence intervention effectiveness (Tomasone, Flood, et al. 2018). For example, support from health and fitness professionals has been touted as important for enhancing physical activity participation among persons with SCI (Giouridis et al. 2021; Williams et al. 2017). Among included studies, the integration of health and fitness professionals was seen in different delivery formats. Several interventions included coach-counselling as a component and the counselling was delivered by a health or fitness professional (Arbour-Nicitopoulos et al. 2014; Chemtob et al. 2019; Ma et al. 2019; Nooijen et al. 2016; Tomasone, Arbour-Nicitopoulos, et al. 2018; Zemper et al. 2003); or a trained peer (Latimer-Cheung et al. 2013). Of note, two interventions utilized a group-mediated cognitive behavioural intervention that was delivered by a health and fitness professional but harnessed the power of group-based sessions (Brawley et al. 2013; Jeske et al. 2020). Several interventions included structured and supervised physical activity programs where persons with SCI would exercise with supervision from a health or fitness professional (De Oliveira et al. 2016; Kooijmans et al. 2017; Pelletier et al. 2014). Other interventions offered home-based physical activity support by a health and fitness professional (Dolbow et al. 2012; Thomas et al. 2011; Warms et al. 2004; Wise et al. 2009) and one study included both a health and fitness professional along with a peer (Latimer-Cheung et al. 2013). Variety in intervention tailoring, dose and delivery mode was also evident. Researchers are encouraged to explore these additional aspects of intervention design and fully report all intervention details, not just strategies employed in interventions, so that future syntheses can make recommendations. Using reporting guidelines, such as the TIDieR checklist (Hoffmann et al. 2014) will facilitate complete reporting of intervention descriptions.

Finally, the synthesis of the included interventions points to several additional areas for future research. One intervention aimed to enhance physical activity behaviour alongside other health behaviours among persons with SCI (Zemper et al. 2003). The utility of multiple behaviour change interventions among persons with SCI remains unknown and is a fruitful avenue for future research. While most behavioural interventions integrated behavioural strategies, few, if any studies were explicit about providing training to participants with SCI about independent use of the strategies for self-management of physical activity beyond the intervention period. Future interventions should seek to train participants in how to use behavioural strategies (e.g., goal setting, action planning) without guidance from interventionists, with a goal to foster long-term behaviour change. Finally, and stemming from this point, is that most included studies examined the impact of interventions immediately following the intervention period, and most interventions occur over a relatively short period. Given physical activity behaviour requires sustained effort over a person's lifetime, interventionists need to consider designing interventions that foster long-term change in psychosocial variables and physical activity participation. Extending intervention studies by including a follow-up period would begin to establish this needed evidence base.

Conclusion

There is level 1b evidence from one RCT that informational interventions are effective for increasing physical activity-related psychosocial variables among persons with SCI.

There is level 1a evidence from three RCTs, as well as support from three lower quality RCTs and four additional studies, that behavioural interventions are effective for increasing physical activity-related psychosocial variables among persons with SCI.

There is level 1a evidence from four RCTs, as well as support from four lower quality RCTs, one prospective controlled trial, and five additional studies, that behavioural interventions are effective for increasing physical activity behaviour among persons with SCI.

Future research should seek to fully employ behavioural theory throughout intervention design and evaluation, conduct a process evaluation to consider additional intervention components that influence effectiveness (e.g., dose, tailoring, delivery mode, provider), and design interventions that foster and evaluate long-term changes in LTPA psychosocial variables and participation.

3.3 Tools to Support Physical Activity Dissemination and Implementation

Knowledge translation is the broad umbrella term that aims to address the 'know-do' gap and move research findings into the hands of those for whom the research is intended (Straus et al. 2013). Within the scope of knowledge translation, dissemination is the active process of making knowledge users aware of evidence (Straus et al. 2013). Implementation practice and science are the use and study of strategies to support putting evidence into practice, respectively (Straus et al. 2013).

There is a growing body of physical activity intervention literature for people with SCI (see Section 3.2). How to best support translation (e.g., dissemination or implementation) of those interventions to non-research settings is an identified gap in improving physical activity participation in this population (Giouridis et al. 2021). A recent scoping review of studies examining physical activity promotion by health and exercise professionals for people with SCI reported SCI-specific resources and training are needed to help address the 'know-do' gap in this field (Giouridis et al. 2021). High-quality physical activity resources are available from sources like SCI Action Canada and the SCI Physical Activity Guidelines to support health care professionals and people with SCI to participate in physical activity. The present review aims to pull from recent research directly evaluating *evidence-informed* tools and strategies to support dissemination and implementation of physical activity in clinical and community settings. Specifically, the included tools and strategies are designed to support physical activity promotion amongst providers or physical activity participation among people with SCI.

Table 6. Tools and Strategies to Support Physical Activity Dissemination & Implementation

Author Year Country Research Design Score Total Sample Size	Methods	Outcome
Ma et al. (2020) (Part 1) Canada Observational N=300	Phase 1: Systematic reviews and meta-analysis. **No Intervention:** Two systematic reviews and a meta-analysis (provided the evidence base for the PA intervention). A mix of SCI-specific and general physical disability evidence was used.	1. Optimal intervention delivery should be tailored and include (1) education on safety, PA guidelines, and behaviour change techniques, (2) referral to other peers, local

	Phase 2: Key informant interviews with people with SCI (N=26) **Population:** Age range=31-64 yr, Level of injury=C5-L2; Time post injury= 1.2–43.0 yr. **Intervention:** Open-ended questions were administered to understand participants' experiences or recommendations for strategies that were or were not helpful for engaging in PA from their physiotherapists. Phase 3: National survey of physiotherapists (N=239) **Intervention:** A national survey was employed to assess: (a) whether physiotherapists wanted an intervention to promote PA to clients with SCI; (b) physiotherapists' intervention needs and barriers to promoting PA; and (c) their intervention delivery preferences. Phase 4: Expert panel meeting (N=10) Phase 4 **Population:** People with SCI (paraplegia and tetraplegia, n = 5), inpatient, outpatient, and private practice physiotherapists (n = 5), a physiatrist, and behaviour change researchers (n = 2). **Intervention:** The panel experts discussed and identified the most relevant results from Phases 1 to 3, highlighted missing information, and developed strategies for disseminating the PA intervention. **Outcome Measures:** A modified theoretical domains framework (TDF) measure was used to evaluate implementation determinants (i.e., barriers identified in Phase 3 such as knowledge, confidence, and resources).	programs, and health professionals, and (3) adapted exercise prescriptions.
Ma et al. (2020) (Part 2) Canada RCT PEDro=4 N= 20	Phase 5: PA intervention content evaluation—randomized controlled trial of intervention training and implementation determinants among physiotherapists (N=20) **Population:** Gender: Females=16, Males=4; Mean Years of Practice=16.6 yr. **Interventions:** Intervention Group (n=10): physiotherapists were trained in the PA intervention content in a 1 h, individual education session delivered virtually. Participants were also provided with an electronic copy of the developed PA	1. Following intervention implementation training, physiotherapists in the intervention group demonstrated stronger tested and perceived knowledge, skills, resources, and confidence for promoting PA to people with SCI, compared to physiotherapists in the control group ($p < 0.05$).

	intervention which included a 50-page toolkit outlining intervention strategies and the SCI exercise guidelines at the end of the training; Control Group (n=10): Waitlist (no intervention). **Outcome Measures:** A modified affordability, practicability, effectiveness, acceptability, safety, and equity (APEASE)-criteria measure was implemented to assess participants' perceptions on the feasibility of implementing the PA intervention in the physiotherapist setting; a test was administered comprised of 20 true or false questions to assess knowledge of SCI-specific PA information (e.g., exercise safety considerations, exercise guidelines and effective-behaviour change techniques). A modified theoretical domains framework (TDF) measure was used to evaluate implementation determinants.	
Tomasone et al. (2018) Canada Pre-Post $N_{initial}$=46 N_{final}=25	**Population:** Age=51.46±12.36yr.; Gender: males=23, females=22, not reported=1; Level of injury: paraplegia=23, tetraplegia=21, not reported=2; Time since injury=17.00±17.59yr. **Intervention:** Participants completed informational/behavioural phone call counselling sessions to explore the implementation correlates of change in leisure time physical activity (LTPA) intentions and behavior in the second phase of Get In Motion (GIM). **Outcome Measures:** LTPA Intentions, LTPA Behaviours, Counselling Session Checklist, Client Reflection.	2. The means for all measures of implementation dose and content were greater between baseline to 2 months than 2 to 6 months ($p \le 0.02$). 3. Informational strategies were discussed significantly more times than behavioral strategies between 2 and 6 months ($p<0.001$). 4. Changes in aerobic MVPA between baseline to 6 months were significantly related to total session duration, total number of sessions, and the number of times that informational and behavioral strategies were discussed over the 6-month period ($p<0.05$). 5. Measures of intervention dose and content were also significantly positively related ($p<0.01$). 6. Clients' ratings of credibility were significantly related to changes in aerobic MVPA,

		as well as total session duration, total number of sessions, and number of times behavioral strategies were discussed ($p<0.05$). 7. Clients' perception of the personal importance of the content discussed during counseling sessions was significantly related to total session duration, total number of sessions, and number of times behavioral strategies were discussed over the 6-month service ($p<0.01$).
Salci et al. (2016) Canada Pre-Post N=12	**Population:** Individuals with SCI=6, Exercise trainers for SCI=6; Age: 20+yr; Gender: males=8, females=4. **Intervention:** Participants engaged in an online program (Active Living Leaders Training Program) and received a handbook covering leisure time physical activity (LTPA) knowledge, transformational leadership skills and practice interactions. Assessments at baseline, post-program and follow-up survey 6mo later. **Outcome Measures:** Self-efficacy measure.	1. Self-efficacy to speak about LTPA did not significantly differ between time points, nor did self-efficacy to encourage LTPA. 2. Of those that completed follow-up (n=9), 8 had spoken to someone with a disability about LTPA since completing the program and 7 had shared one of the resources.
Gainforth et al. (2015) Canada Pre-Post N=13	**Population:** Mean age: 52.77±9.16yr; Mean time since injury: 18.46±14.51yr; Gender: males=7, females=6; Level of injury: tetraplegia=7. **Intervention:** Individuals attended a 4hr brief action planning (BAP) workshop, which began with a 1hr didactic presentation about BAP followed by 3hr of practice with feedback/instruction as well as audio recordings of a peer with SCI using BAP to promote physical activity to a mentee. Measures were taken at baseline, immediately post-training, and 1mo follow up. **Outcome Measures:** Leisure Time Physical Activity Questionnaire for People with Spinal Cord Injury (LTPAQ-SCI), Motivational Interviewing Treatment Integrity scale, Likert scale, Theory of planned behavior questionnaire.	1. BAP and motivational interviewing competence significantly increased after training ($p<0.05$). 2. Training satisfaction was very positive with all means falling above the scale midpoint. 3. Perceived behavioral control to use BAP increased from baseline to post ($p<0.05$), but was not maintained at follow up ($p>0.05$).

Discussion

Although currently a small body of literature, these studies represent the evolution of SCI physical activity interventions shifting into clinical and community settings. These findings show that co-creation of material and integrating behaviour change techniques into supports for both people with SCI (see section 3.2) and their health care professionals (e.g., demonstration, practice, and feedback as shown in Gainforth et al. (2015) are key features of implementation. Implementation factors such as increased intervention dose, the use of both informational and behavioural strategies, and clients' perceptions of service credibility may improve physical activity counseling session effectiveness on physical activity behaviour (Tomasone, Arbour-Nicitopoulos, et al. 2018). Future research and initiatives are needed to inform how to best support end-users in the uptake and delivery of material.

Five evidence-informed tools to support physical activity intervention dissemination and implementation were identified in the search. Active Living Leaders is an online physical activity mentorship training program designed to be delivered by peers or people who may be in contact with adults with SCI (Salci et al. 2016). Get In Motion is a free physical activity coaching service delivered over the phone for people with physical disabilities, including SCI (Tomasone, Arbour-Nicitopoulos, et al. 2018). The Canadian SCI Physical Activity Guidelines and the Scientific Exercise Guidelines for Adults with SCI are knowledge translation tools developed to share the findings of the international scientific SCI exercise guidelines (Goosey-Tolfrey et al. 2018; Hoekstra et al. 2020; Martin Ginis et al. 2018). The use of the guidelines are currently being assessed in conjunction with behavioural interventions in a randomized controlled trial of the effects of exercise on chronic pain (Martin Ginis et al. 2020). The Canadian SCI Physical Activity Guidelines are also undergoing evaluation in a type II hybrid implementation-effectiveness trial assessing the uptake of physical activity coaching among hospital physiotherapists and SCI peers and the impact of this coaching on physical activity participation among people with SCI (Ma et al. 2022)

The ProACTIVE SCI Toolkit was developed to support physiotherapists to promote and prescribe physical activity to clients with SCI. Its use in conjunction with a behavioural intervention has demonstrated significant, medium- to large- sized effects on physical activity, cardiorespiratory fitness, and psychosocial predictors of physical activity among people with SCI when administered in the research setting (Ma et al. 2019). Its effectiveness in the hospital and community setting is currently undergoing evaluation in the above-described Type II hybrid-implementation effectiveness trial (Ma et al. 2022). Importantly, all of the tools described in this section were developed in collaboration with an expert panel of SCI researchers and stakeholders. The latter 3 tools were developed using an adapted version of the Appraisal of Guidelines, Research, and Evaluation (AGREE)- II instrument, supporting the rigour and transparency of their development process (Brouwers et al. 2016).

Though not within the scope of the present review, it is important to note the limitation of tools and resources alone to affect physical activity promotion and participation behaviour. While resources (e.g., informational interventions) may improve theory-based determinants of behaviour, additional strategies are likely needed to optimize physical activity behaviour (Michie et al. 2008). These tools should be paired with i) behavioural strategies (described in section 3.2),

ii) the use of implementation theories in development and evaluation (examples used in the SCI literature include the Knowledge to Action Framework, the Reach, Effectiveness, Adoption, Implementation, Maintenance [RE-AIM] framework, and Quality Implementation Framework (Esmail et al. 2020; Glasgow & Estabrooks, 2018; Graham et al. 2006; Ma et al. 2022; Meyers et al. 2012; Sweet et al. 2017; Tomasone, Arbour-Nicitopoulos, et al. 2018), and iii) adopted in collaboration with stakeholders to understand needs, adaptations, and factors that affect the use of these tools in the local context (Graham et al. 2006) for SCI-specific guiding principles for involving research users throughout the research process, i.e., integrated knowledge translation, see (Gainforth et al. 2021).

Conclusion

There is level 1b evidence from one RCT that a knowledge translation tool supported by a behavioural intervention can improve physical activity behaviour among people with SCI.

There is level 4 evidence from one pre-post study that demonstration, practice, and feedback are important behaviour change techniques to include when training interventionists to deliver PA strategies.

There is level 4 evidence from one pre-post study that intervention dose, the use of both informational and behavioural strategies, and clients' perceptions of service credibility are important physical activity session implementation factors.

Addressing physical activity behaviour for people with SCI needs to extend beyond passive education. While resources such as guidelines and toolkits help summarize available physical activity evidence, integrating behaviour change techniques at both the participant (i.e., individual with SCI) and the health professional level are needed to support increasing physical activity behaviour in non-research settings.

4 Gaps in the Evidence

Several gaps in the literature were identified in this module. First, more comprehensive population-level data is required to fully understand physical activity participation levels in the SCI population (Wilroy & Knowlden, 2016). Existing studies are limited by the challenges in physical activity measurement in this population, inconsistencies in reporting, a focus on aerobic (rather than distinguishing between aerobic and strength-based) activity, and a predominance of studies from high-income countries. Future research advances in physical activity measurement and reporting are needed.

Second, there is a paucity of research describing the factors (i.e., correlates, barriers, facilitators) that influence participation in physical activity among persons with SCI in low- and middle-income countries. A starting point for intervention development in low- and middle-income countries is to explore the multilevel factors influencing participation. In high-income countries, researchers should move beyond reporting of correlates, barriers and facilitators to participation, to incorporating this knowledge into interventions that aim to alleviate barriers and increase physical activity-related psychosocial and behavioural outcomes.

Interventions that aim to increase physical activity participation among persons with SCI have continued to evolve in the past decade. While both informational and behavioural strategies are promising to include in interventions aimed at physical activity-related psychosocial and behavioural outcomes, high-quality experimental designs testing the impact of a given strategy with larger sample sizes are required. Incorporating theory into the design and evaluation of the intervention would offer guidance about the mechanisms of change for these interventions (Best et al. 2017). Given physical activity participation requires sustained effort over time, future intervention research should focus on evaluating the long-term impact of interventions (Best et al. 2017). In addition, authors are encouraged to include more specific and thorough intervention descriptions in publications to allow for replication/future development to build the existing literature base (Tomasone, Flood, et al. 2018).

Finally, given the recent upwelling of interest in translating physical activity promotion efforts in community and clinical settings, more studies that unpack implementation strategies that support intervention uptake and effectiveness on physical activity behaviour are required (Best et al. 2017). This translational research should be done in partnership with stakeholders from the SCI community (e.g., persons with lived experience, community organizations, health care providers) to ensure feasibility and maximal impact on physical activity participation among persons with SCI (Best et al. 2017); the use of SCI-specific principles to guide this collaborative work is encouraged (Gainforth et al. 2021).

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Abbreviations

AGREE- II	Appraisal of Guidelines, Research, and Evaluation
AIS	American Spinal Injury Association Impairment Scale
MET	Metabolic Equivalent
RCT	Randomized Controlled Trial
RE-AIM	Reach, Effectiveness, Adoption, Implementation, Maintenance
SCI	Spinal Cord Injury
WHO	World Health Organization