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Physical Activity Following Spinal Cord Injury: Psychosocial Outcomes

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Key Points

Physical activity and Depression and Anxiety

- While some studies found no significant effect/relationship between leisure time physical activity (LTPA) and depressive symptoms, most studies show that participation in LTPA can reduce depressive symptoms among persons with spinal cord injury (SCI).
- There is conflicting evidence on the relationship between LTPA and anxiety. Some studies found no significant effect/relationship between LTPA and symptoms of anxiety while others reported LTPA participation is related to lower symptoms of anxiety.

Physical activity and Quality of Life

- Overall, LTPA is effective at increasing objective and subjective quality of life (QOL) among persons with SCI with very few studies showing a significant negative relationship and relatively few studies showing no significant relationship.

Physical activity and Participation-related outcomes

- LTPA-based interventions appear to be effective for increasing participation in daily and social activities among persons with SCI. However, only a few studies have been reported, limiting the strength of the evidence.

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1.0 Executive Summary

Beyond the physical and physiological benefits of physical activity for persons with spinal cord injury (SCI), physical activity has reported benefits on psychosocial outcomes. This chapter summarizes the evidence examining the relationship between leisure time physical activity (LTPA; physical activity that one chooses to do in their spare time), and three categories of psychosocial outcomes: anxiety and depression, quality of life (QOL), and participation in daily and social activities.

This chapter begins with a look at the relationship between LTPA and anxiety and depression. These relationships were examined for symptoms of and/or a clinical diagnosis of anxiety and depression. In total, 26 studies were identified with 9 being observational and 17 interventional. No studies examined just anxiety, 16 examined depression, and 10 examined both anxiety and depression. Almost all studies were conducted in high income countries, particularly Canada and the United States. Overall, there was a positive or no relationship described between the physical activity and both anxiety and depression symptoms/outcomes. Given most studies examined symptoms of anxiety and depression in non-clinical samples (i.e., without a diagnosis), it can be concluded that LTPA is safe for people with SCI without a clinical diagnosis of anxiety and depression. In fact, participating in LTPA will likely improve mood for this segment of the SCI population. Unfortunately, little research has examined the role of LTPA among people with SCI who have a clinical anxiety/depression diagnosis. Therefore, no conclusion can be made regarding the role of LTPA on anxiety/depression among people with SCI who have a diagnosis. Further research is needed to examine individuals who have a SCI and a clinical diagnosis of an anxiety or depressive disorder, and studies should prioritize anxiety/depression measures as the primary outcome of LTPA interventions. A focus on understanding whether LTPA is safe for these samples and the ideal dosage of LTPA (if safe) is needed.

Next, we review studies that examine the relationship between LTPA participation and QOL. In line with Dijkers (2003), we operationalize QOL as both objective QOL ("what I have"; the congruency between one's achievements and one's expectations) and subjective QOL ("what I think or feel about what I have"; one's thoughts and feelings what one's achievements meeting one's expectations). The 45 included studies used a variety of research designs (e.g., randomized controlled trials, pre-post, observational/correlational) and examined various types of LTPA – for example, yoga and tai chi, exercise programs, sports – as well as LTPA counselling/coaching interventions. Nearly all the research to date examining the LTPA-QOL relationship has been from high income countries. Overall, participation in LTPA was found to be positively associated with both objective and subjective QOL among individuals with SCI, with very few studies showing a significant negative relationship and relatively few studies showing no significant relationship between LTPA and QOL. The field is beginning to place equal emphasis on objective and subjective QOL, yet more research about the LTPA-subjective QOL relationship is required as the enhanced focus on subjective QOL is relatively recent and findings remain uncertain. The mixed findings about the LTPA-QOL relationship

likely stems from the complexity in the conceptualization and measurement of the LTPA relationship, specifically the assessment of both objective and subjective QOL in the same study, the use of two different subscales to assess either objective or subjective QOL within a given study, the moderating role of participant characteristics (i.e., injury level and characteristics) on the LTPA-QOL relationship, and underpowered analyses due to small sample sizes. Future research that identifies which QOL measures are most responsive to the effects of LTPA is warranted. In addition, future research that explores the psychosocial mechanisms by which LTPA influences objective and subjective QOL is needed.

This chapter concludes with an exploration of the relationship between LTPA and participation in daily and social activities. The nine included studies used various research designs and were primarily from high-income countries. Across included studies, LTPA had a positive relationship with participation in daily and social activities. A greater number of studies is required to confirm these promising results. We recommend that future studies examine the relationships between types of LTPA and specific groupings of participation activities, as well as consider the settings in which interventions are delivered; such findings would enhance the design of LTPA interventions that aim to promote participation. Further work is also required to examine the nuances between the impact of LTPA on patient-perceived vs. society-perceived participation-related outcomes.

2.0 Introduction

As noted in the other SCIRE chapters, physical activity and specifically, leisure time physical activity (LTPA) has multiple physiological and physical benefits for individuals with spinal cord injury (SCI). In recent years, studies have examined the benefits of LTPA on psychological and participation-related outcomes. The present chapter aims to describe the research that examined the role LTPA plays on psychological outcomes, namely anxiety and depression, quality of life (QOL), and participation. We review the evidence on the relationship between LTPA and these outcomes among observational and longitudinal studies, as well as describe the effectiveness of LTPA interventions on enhancing these outcomes.

3.0 Relationship between Physical Activity and Psychological Outcomes

For this chapter, psychological outcomes are defined as self-reported psychological health, specifically anxiety and depression, as well as QOL. Anxiety and depression are complicated and compounded in SCI as symptoms of anxiety and depression are to be expected, but one may also be at an increased risk for an anxiety or depression disorder (Le & Dorstyn, 2016; Williams & Murray, 2015)Depression is defined as persistent feelings of sadness, hopelessness, and a loss of interest in previously enjoyed activities (WHO, 2022). Clinical depression, or a major depressive disorder, is a medical diagnosis based on the presence of five or more symptoms of depression that are present for at least 2 weeks continuously (American Psychiatric Association, 2013). There are different types of anxiety disorders to which are characterized as excessive fear or unease that differs from expected situational feelings of nervousness or anxiousness (American Psychiatric Association, 2022). As there is a lack of physical activity research including individuals with SCI and a diagnosed anxiety or depressive disorder, we broaden our search to include symptoms of anxiety and depression for this chapter.

Regarding QOL, we approached the conceptualization of QOL from an objective and subjective standpoint (Dijkers, 2003). Objective QOL is defined as “what I have” and thus the congruency between one’s achievements and one’s expectations. Subjective QOL was operationalized as “what I think or feel about what I have”, involving one’s thoughts and feelings regarding whether one’s achievements meet one’s expectations (Dijkers, 2003).

Research examining LTPA and these psychological outcomes has grown in the past decade. In their review, Martin Ginis et al. (2010) found that, across 21 studies, LTPA had small-to-medium sized relationship with lower depression symptoms and higher life satisfaction (subjective QOL). They urged future research to examine the role of LTPA on other psychological outcomes and subjective

evaluations of quality of life. To broaden the examination of the LTPA and QOL relationships, Tomasone et al. (2013) conducted a systematic review examining LTPA and QOL and found that of the 110 analyses examined (from 33 studies), 84 found a positive relationship between LTPA and quality of life, 21 no relationship, and only 5 negative significant relationship. The majority of the studies were non-experimental studies and only 5 of the 33 studies were randomized controlled trials. There continues to be a need to understand the relationship between LTPA and these psychological outcomes, including the impact of LTPA interventions on these outcomes.

3.1 Depression and Anxiety

Anxiety and depression are two of the most commonly-measured components of psychological well-being in SCI. Symptoms of anxiety and/or depression are commonly-reported concerns amongst individuals with SCI, their care partners and/or healthcare providers, and are associated with negative outcomes among individuals with SCI including lower functional independence, more secondary complications, and less community and social integration (Fann et al., 2011). Unfortunately, the likeliness of individuals with SCI experiencing anxiety or depression is significantly higher than age-matched control without SCI (Williams & Murray, 2015). However, the outcome measures used to capture and evaluate symptoms of anxiety and depression in research vary, making the comparison of findings difficult. The goal for this section is to summarize the current state of the research investigating the role of LTPA on symptoms of anxiety and/or depression.

Table 1. Physical Activity for Depression and Anxiety following SCI

Author (Year) Country Research Design PEDro Score for RCTs Total Sample Size	**Methods**	**Outcome**
Akkurt et al. 2017 Turkey RCT PEDro=5 N=33	**Population:** Median age: Intervention group=33yr, Control group=37yr; Gender: males=29, females=4; Time since injury=>1mo; Level of injury: C=1, T=22, L=10; Severity of injury: AIS A=19, B=1, C=10, D=3. **Intervention:** Participants were enrolled in a 12wk program comparing arm ergometer exercises and general rehab exercises to those that receive only general rehab exercises.	1. No intergroup differences were seen in HADS and CES-D.

	Outcome Measures: Center for Epidemiologic Studies Depression Scale (CES-D) and Hospital Anxiety and Depression Scale (HADS).	
Chemtob et al. 2019 Canada RCT PEDro=9 $N_{(start)}$=24 $N_{(end)}$=22	**Population:** Age=51.64±12.13yr.; Gender: males=16, females=8; Level of injury: paraplegia=24, quadriplegia=0; Level of severity: Not reported; Time since injury=15.45±12.85yr. **Intervention:** Participants were randomized to either an intervention or control group. The intervention group received one, 1-hour counselling session per week for 8 weeks via online video chat with the intent to motivate patients to increase their leisure-time physical activity, while the control group continued their regular routine. **Outcome Measures:** Patient-Health Questionnaire-9 (PHQ-9).	1. Small effect sizes were found to favour the intervention group at 6 and 10 weeks for improvements in PHQ-9 score.
Coulter et al. 2017 United Kingdom RCT PEDro=6 $N_{Initial}$=24, N_{Final}=21	**Population**: *Intervention Group:* Mean age: 51.5yr; Gender: males=9, females=7; Level of injury: C3/4–L3; Severity of injury: complete=7, Incomplete=9. *Control Group:* Mean Age: 48.1yr; Gender: males=5, females=3; Level of injury: C3/4–L3, Severity of injury: Complete=5, Incomplete=3. **Intervention:** Intervention Group: an 8wk web-based physiotherapy (2x/wk). Individual exercise programmes were prescribed based on participants' abilities. Control Group: Usual care. **Outcome Measures:** Hospital Anxiety and Depression Scale (HADS)	1. No statistically significant difference between the intervention and control groups on the HADS depression and HADS anxiety subscale scores following the intervention.
Curtis et al. 2017 Canada RCT Crossover PEDro=6 N=22	**Population:** *Yoga group (n=10):* Mean age=47.9±19.5yr; Gender: Not reported; Level of injury: paraplegia=6, tetraplegia=0, ambulatory/unspecified=4; Severity of injury: complete=2, incomplete/disease-related=8. *Control group (n=12):* Mean age=54.8±10.1yr; Gender: Not reported; Level of injury: paraplegia=4, tetraplegia=4, ambulatory/unspecified=4; Severity of	1. Yoga group had significantly lower scores for depression than the waitlist control group ($p<0.05$). 2. No differences were found for anxiety by group. 3. Fixed-factor models showed significantly

	injury: complete=5, incomplete/disease-related=7. **Intervention:** Participants were randomized to a 2x/wk for 6wk Iyengar yoga group or a wait-listed control group. **Outcome Measures:** Hospital Anxiety and Depression Scale (HADS)	lower HADS scores postintervention compared to preintervention ($p<0.05$) with time being the main predictor of HADS-D (depression) scores ($p<0.05$).
Diego et al. 2002 USA RCT PEDro=8 N=20	**Population:** Mean age=39yr; Gender: males=15, females=5; Level of injury: tetraplegia; Time since injury=>1yr. **Intervention:** One group received a 40 min massage 2x/wk for 5wk by a massage therapist while the other was taught a range of motion exercise routine that they performed 2x/wk for 5wk on their own. **Outcome Measures:** State Trait Anxiety Inventory (STAI), Center for Epidemiologic Studies Depression Scale (CES-D).	1. On pre-posttreatment days, the massage group had lower anxiety scores than the range of motion exercise group ($p < .01$) 2. On pre-post intervention assessments, the massage groups had greater decreases in depression scores compared to range of motion exercise group ($p < .05$).
Hicks et al. 2003 Canada RCT PEDro=8 $N_{Initial}$=43 N_{Final}=32	**Population:** Age=19-65yr; Time since injury=1-24yr. **Intervention:** Experimental group participated in a progressive exercise training program twice weekly for 9mo on alternative day's 90-120 min starting with warm up, upper extremity stretching, and 15 to 30 min of aerobic training. As the rate of perceived exertion decreased, workload was increased. Some resistance training took place. **Outcome Measures** Centre for Epidemiological Studies Depression Scale (CES-D).	1. Exercisers reported significantly fewer depressive symptoms than the controls. ($p<0.05$).
Latimer et al. 2004 Canada RCT PEDro=6 $N_{Initial}$=34, N_{Final}=21	**Population:** *Intervention group*: Mean age: 38.27yr; Gender: males=3, females=8; Level of injury: Tetraplegia=7, Paraplegia=4; Severity of injury: ASIA A=5, ASIA B=1, ASIA C=3, ASIA D=1; Mean time post-injury:	1. Exercise group had lower depression than the control group. ($p<.05$)

	10.54yr. *Control group:* Mean age: 43.08yr; Gender: males=2, females=8; Level of injury: Tetraplegia=3, Paraplegia=7; Severity of injury: ASIA A=3, ASIA B=1, ASIA C=3, ASIA D=3; Mean time post-injury: 14.58yr. **Intervention**: Intervention group: 9mo exercise program - 2d/wk, small group exercise sessions, 60-90min duration consisting of stretching, arm ergometry & resistance exercise with student volunteer personal trainers. Control group: Asked to continue normal daily activities and not begin an exercise routine within 9mo although provided with an opportunity for education. **Outcome Measures**: Center for Epidemiological Studies Depression Scale (CES-D).	
Martin Ginis et al. 2003 Canada RCT PEDro=6 $N_{Initial}$=34 N_{Final}=34	**Population:** Mean age=8.6yr; Gender: males=23, females=11; Mean time post injury: 10.4yr. **Intervention:** Intervention group: 5min of stretching, 15-30min of aerobic arm ergometry exercise & 45-60min of resistance exercise, 2d/wk, in small groups. Control group: Asked to continue normal daily activities and not begin an exercise routine for 3mo **Outcome Measures:** Center for Epidemiologic Studies Depression Scale (CES-D).	1. After 3 months, when compared to controls, exercisers had decreased depression (p=0.02).
Alajam et al. 2020 USA Pre-Post $N_{Initial}$=15, N_{Final}=11	**Population:** SCI; Mean age= 38±10yr; Gender: males=8, females=3; Level of injury: T3-L1; Mean time post-injury: 8.72±10.40yr. **Intervention:** Participants received walking training, 3 sessions/wk for 8wk. Participants were trained on a treadmill using a novel assistive gait training device consisting of a thigh brace attached to a pulley cable designed to assist with leg flexion. **Outcome Measures:** Depression Anxiety Stress Scales-21 (DASS-21).	1. Statistically significant decrease in mean scores for depression (2.36 point decrease, p<0.01), anxiety (1.45-point decrease, p<0.05), and stress (2.09-point decrease, p<0.01) after training.

Allin et al. 2020 Canada Pre-Post $N_{initial}$=11 N_{final}=10	**Population:** Age=43±8yr.; Gender: males=4, females=7; Level of injury: paraplegia=5, tetraplegia=3, not reported=3; Level of severity: Not reported; Time since injury=20±12yr. **Intervention:** Participants took part in a self-paced, six-session self-management program guided by a trained peer health coach. The program lasted between 35-88 days with a total of 6 coaching sessions. **Outcome Measures:** Personal Health Questionnaire Depression Scale [PHQ-9])	1. PHQ-9 scores decreased, showing improvements, but did not reach significance (p=0.27).
Crane et al. 2017 USA Pre-Post $N_{Initial}$=89 N_{Final}=45	**Population:** Mean age=43.8±15.3yr; Gender: males=34, females=11; Level of injury: Paraplegia=11, Tetraplegia (C1-C4)=4, Tetraplegia (C5-C8)=8, Other=22; Severity of injury: AIS A/B=23, C/D=22. **Intervention:** Participants engaged in a 3mo physical therapy group exercise class, twice per wk. **Outcome Measures:** Patient Health Questionnaire-2 to assess depressive mood	1. Total depression scores were significantly lower at post-intervention assessment (p<0.05).
Guest et al. 1997 USA Pre-Post N=15	**Population:** Traumatic complete paraplegics; Gender: males=12, females=3; Mean age=28.8yr; Mean time post injury=3.8yr. **Intervention:** Electrically stimulated walking program-32-sessions, using the Parastep® FES ambulation system. **Outcome Measures:** Beck Depression Inventory (BDI).	1. BDI decreased after electrically stimulated walking (p<0.05).
Hicks et al. 2005 Canada Pre-Post N=14	**Population:** Chronic incomplete SCI: N=14; Tetraplegic=11, Paraplegic=3; Gender: males=11, females=3; Age range=20-53yr; Mean time post injury=7.4yr; ASIA: B=2, C=12. **Intervention:** Body weight supported treadmill training (BWSTT) – up to 45 min, 3x/week, 144 sessions (12mo). **Outcome Measures:** Center for Epidemiologic Studies Depression Scale (CES-D).	1. No change in depression or perceived health (p>.05).

Kennedy et al. 2006 United Kingdom Pre-Post N=35	**Population:** Gender: males=30, females=5; Age: 18-61yr, Level of injury: paraplegia=20, tetraplegia=15. **Intervention:** 'Back-Up Trust' sports participation program: 1wk participation in single or multi-activity course in an integrated, residential environment. Activities include skiing, horseback riding, waterskiing, canoeing, rappelling and gliding. Questionnaires were completed at baseline and end of 1wk activity courses **Outcome Measures:** Hospital Anxiety and Depression Scale (HADS).	1. HADS scores demonstrated significant ($p<0.01$) improvement in anxiety levels but not in depression levels over the duration of the course.
Martin Ginis & Latimer 2007 Canada Pre-Post N=14	**Population:** SCI; Mean age: 28.8yr; Gender: males=11, females=3; Level of injury: incomplete, ASIA B and C; Mean time since injury: 7.4yr; Chronicity: chronic. **Intervention**: Participants performed three exercise sessions of body weight supported treadmill training (BWSTT). Each exercise session consisted of three separate bouts of BWSTT. Depending on the participant's tolerance, each bout lasted from 5 to 15 min with a 10 min rest between bouts. **Outcome Measures:** Profile of Mood States (POMS),	1. Participants showed a nonsignificant small-to-medium sized improvement in the POMS in session 1, and a nonsignificant decrease in the POMS in session 2 and 3 ($p>.05$).
Shem et al. 2016 USA Pre-Post $N_{Initial}=26$, $N_{Final}=10$	**Population:** SCI; Mean age: 49.8±13.0yr; Gender: males=14, females=12; Level of injury: tetraplegic=16, Level of injury: paraplegic=6, unknown=4, Mean time post-injury: 25.1yr. **Intervention:** Participants completed a 12-week seated Tai Chi course consisting of weekly sessions (one 90-min session/wk). **Outcome Measures:** Beck Depression Inventory–II (BDI–II)	1. No changes in the long-term effect surveys of BDI between the first and the last sessions were observed.
Warms et al. 2004 USA Pre-Post N=16	**Population:** Gender: males=13, females=3; Mean age=43.2yr; Mean time post injury=14.4yr. **Intervention:** "Be Active in Life" program: included educational	1. No significant change in depression was observed ($p>0.05$).

	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. 8 min each). Program lasted for 6wk, and had a final follow up 2wk post-completion. **Outcome Measures:** Center for Epidemiologic Studies Depression Scale (CES-D)	
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. *Non-sport participants (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. Groups were sport and non-sport participants. **Outcome Measures:** Centre for Epidemiological Studies Depression Scale (CES-D), State Tait Anxiety Inventory (STAI).	1. No significant differences were found for depression between the groups (p=0.099). 1. Non sport participants had a significantly higher score in trait anxiety than sport participants (p=0.048).
Gioia et al. 2006 Italy Observational N=137	**Population:** SCI*:* Mean age: 34.21±11.36yr; Gender: males=137, females=0; Time since injury: 5-10yr; Level of Injury: C5 or below; Neurological status: paraplegic=85; tetraplegic=52. **No Intervention:** Wheelchair users were recruited to investigate whether sports activity is associated with better psychosocial outcomes. Participants were divided into a high activity and no activity group. **Outcome Measures:** State-Trait Anxiety Inventory (STAI), Questionnaire for Depression.	1. ANOVA showed that there was a significant main effect of participation is sports on psychological outcomes, with less active people scoring higher in anxiety and lower in extraversion ($p<0.05$). 2. Anxiety effectiveness was found to positively correlate with sport activity ($p<0.01$).

Jorgensen et al. 2017 Sweden Observational N=122	**Population:** Mean Age=63±9yr; Gender: Males=86, Females=36; Level of Injury: C1-L5; Severity of Injury: AIS A-C=62, D=60; Mean Time Since Injury=24±12yr. **No Intervention:** Not applicable. Review of data from the Swedish Aging with Spinal Cord Injury Study to assess the presence of depressive symptoms among older adults with long-term spinal cord injury. **Outcome Measures:** Geriatric depression scale-15 (GDS-15), sense of coherence scale, spinal cord lesion-related coping strategies questionnaire, physical activity recall assessment for people with SCI (PARA-SCI).	1. Sense of coherence, the coping strategy acceptance, neuropathic pain and leisure-time physical activity explained 53% of the variance in depressive symptoms. LTPA had a significant, negative relationship with depressive symptoms
Kim et al. 2020 Korea Observational N=103	**Population:** Mean Age=36.71±9.77yr; Gender: Males=91, Females=12; Level of Injury: Cervical=59, Thoracic=39, Lumbrosacral=5; Severity of Injury: AIS A=58, B=36, C=7, D=2; Time Since Injury>1yr. **No Intervention:** Cross-sectional analysis to assess the relationship between physical activity levels and mental health in individuals with SCI. **Outcome Measures:** Godin Leisure-Time Exercise Questionnaire (GLTEQ), Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder-7 (GAD-7).	1. Participants that were the most physically active experienced less depression (PHQ-9; $p<0.001$) and anxiety (GAD-7; $p<0.001$) than those who were the least physically active. 2. Multivariate linear regression analysis showed that reduced physical activity was a significant predictor of depression ($p=0.01$) and anxiety ($p=0.02$).
Muraki et al. 2000 Japan Observational N=169	**Population:** Mean age:42.7yr; Gender: males=169; Level of injury: Tetraplegia=53, Paraplegia=116; Mean time post-injury: 9.23yr. **No Intervention:** Questionnaire. Participants were divided into four groups according to their frequencies of sports activity; High-active (more than three times a week; n=32), Middle-active (once or twice a week, n=41), Low-active (once to three times a month, n=32), and Inactive (no sports participation, n=64).	1. Significant differences in depression (SDS), trait anxiety (STAI), and depression and vigor (POMS) among the groups ($p<0.05$) 2. High-active group showed the lowest scores of depression and trait anxiety, and the highest score of

	Outcome Measures: Questions about the frequency and mode of physical activities, Self-rating Depression Scale (SDS), State-Trait Anxiety Inventory (STAI) and Profiles of Mood States (POMS).	vigor among the four groups. 3. There was no significant difference for any psychological measurements among modes (wheelchair basketball, wheelchair racing, wheelchair tennis and minor modes; (p>0.05).
Sweet et al. 2013 Canada Prospective N=395	**Population:** Age=45.68±14.05yr; Gender: males=298, females=95; Level of injury: paraplegia=190, tetraplegia=194; Level of severity: ASIA A=254, ASIA B/C/D=134; Time since injury=13.51±10.35yr. **No Intervention:** None – prospective design. Using a prospective design, this study examined potential intermediary constructs linking LTPA and QOL in people with SCI. Drawing from previous literature, a longitudinal structural equation model was developed and tested to determine if depression, functional independence, social integration/participation, and self-efficacy mediate the LTPA–QOL relationship. **Outcome Measures:** Leisure Time Physical Activity (LTPA), Depression (Patient Health Questionnaire-9 (PHQ-9).	1. LTPA was significantly related to depression (PHQ-9). 2. Depression was statistically significant mediators of the LTPA-QOL relationship.
Tasiemski and Brewer 2011 Poland Observational N=1034	**Population:** Mean age: 35.93yr; Gender: males=861, females=173; I Level of injury: paraplegia: 49.8%, tetraplegia: 50.2%; Mean time since injury: 9.78yr. **No Intervention:** Questionnaire based study to examine the interrelationships among athletic identity, sport participation, and psychological adjustment **Outcome Measures:** Sport participation, involvement in nonsport	1. Being able to practice one's favorite sport after SCI was associated with lower levels of depression (p<0.001). 2. Team sport participants reported lower anxiety (p<0.005) and depression (p<0.05)

	recreational activities before and after SCI, Hospital Anxiety and Depression Scale (HADS).	than individual sport participants did.
Tawashy et al. 2009 Canada Observational N=49	**Population:** Mean age: 43.7yr; Gender: not reported; Level of injury: Paraplegia=67%; Injury severity: complete=61%; Mean time post-injury: 11.8yr. **No Intervention:** Cross-sectional study to evaluate the relationship between physical activity levels and demographic and secondary complications factors that might relate to physical activity participation. **Outcome Measures:** Physical Activity Recall Assessment for People with SCI (PARA-SCI), Centre for Epidemiological Studies - Depression scale (CESD-10)	1. Higher amounts of mild-intensity activity and total activity were related to less depressive symptoms ($p<0.05$).
VanDerwerker et al. 2020 USA Observational N=1790	**Population:** Gender: males=1324, females=466; Injury: C1-C4 non-ambulatory=175, C5 and below non-ambulatory=1034, Any level, ambulatory=563; Mean time since injury: 13yr. **No Intervention:** Participants completed a mail-in self report survey at two time points (mean 3.29yr apart) and study investigated associations between doing planned exercise and probably major depressive disorder. **Outcome Measures:** Patient Health Questionnaire- 9 (PHQ-9).	1. Participants who did planned exercise three or more times per week at T1 had significantly lower odds of probable major depressive disorder at T2 ($p=0.0042$). 2. Compared to those who had no change, those who worked out more at T2 had significantly lower odds of probable major depressive disorder ($p=0.0005$) and those who did less planned exercise had higher odds ($p=0.005$).

Discussion

Description of studies. Overall, the studies included in this section found a positive or no relationship between LTPA and symptoms of anxiety and depression. Out of the 26 included studies, 9 were observational and 17 were interventional (8 RCTs, and 9 pre-post trials). The majority of the included studies (17/26) were conducted in North America (6 of which were RCTs, 8 pre-post, and 3 observational). Studies conducted outside of North America were observational studies (6/9) and included 1 in Poland, and 1 each from Australia, Italy, Japan, Korea, and Sweden. Out of the 3 intervention studies conducted outside of North America, 2 were from the UK (1 RCT and 1 pre-post), and 1 RCT from Turkey. Therefore, interpretations made in this section are heavily influenced by studies conducted within North America (5 RCTs, 3 pre-post, and 2 observational from Canada, and 1 RCT, 5 pre-post, and 1 observational from the USA). No studies examined just anxiety, but 16 examined depression (4 RCT, 7 pre-post, and 5 observational), and 10 examined both anxiety and depression (4 RCT, 2 pre-post, and 4 observational).

Overview of the LTPA and depression/anxiety relationship. The majority of RCT intervention studies (6/8) provided evidence in favour of the beneficial role of LTPA interventions on decreasing symptoms of depression. Interestingly, 6 of the 9 pre-post studies showed no significant effect of LTPA intervention on depressive symptoms. Anxiety was less studied; only 6/17 intervention studies (4 RCTs and 2 pre-post) included a measure of anxiety. The intervention studies that measured anxiety reported conflicting findings: 3 RCTs showed no significant effect of LTPA interventions on symptoms of anxiety while 1 RCT showed a decrease. Both pre-post studies showed a positive impact of LTPA interventions on decreasing symptoms of anxiety.

There was a large variety in the types of LTPA used in the intervention studies including arm ergometry, web-based physiotherapy exercises, yoga, tai chi, mobility/range of motion programs, activity coaching/counselling, support treadmill training (using body weight support, pulley assistance, or electrical stimulation), sport, and combined exercise programs (including progressive resistance, aerobic, and stretching training). Studies also varied in terms of the target/included SCI population, and in length and dosage of interventions. No obvious trends were seen with regards to type of LTPA intervention and effect on symptoms of anxiety and/or depression. Further, a remaining challenge is that most studies did not sample for individuals affected by anxiety or symptoms of depression and most of the included studies did not set out to primarily target anxiety or depression. With the exception of a few studies, the primary aims of included studies were related to fitness, function (e.g., walking ability) or LTPA behaviour. Another major limitation to fully understanding the role of LTPA on anxiety and depression is that no studies included individuals who were diagnosed with clinical depression and/or an anxiety disorder.

With regards to the observational studies, 5/9 looked at just depression, and 4/9 looked at both anxiety and depression. Among the 9 studies that measured depression, 7 studies showed a negative relationship between LTPA level and symptoms of depression (i.e., as physical activity increased, symptoms of depression decreased), 2 studies however showed no significant relationship between symptoms of depression and LTPA. These same 2 studies did show an inverse relationship between sports participation and symptoms of anxiety. The remaining 2 studies that looked at anxiety also supported the inverse relationship between LTPA levels and anxiety. Similar to intervention studies, the observational studies varied in the type of LTPA investigated: 4 studies looked at sports involvement while the other 5 looked at other types of LTPA. Noteworthy, the 4 studies that focused on sports ranged in sample size from n=121-1034, but 81-100% of these participants were male. Further research exploring the relationship between LTPA and symptoms of anxiety and depression across sex and/or gender is warranted.

Although the majority of observational studies reported significant findings describing the inverse relationship between LTPA levels and symptoms of anxiety and depression, we do not know if LTPA is improving these symptoms OR if having these symptoms preclude individuals with anxiety and depression to be active. It is likely that unique opportunities and behavioural strategies are needed to help support LTPA participation for individuals with anxiety or depression and SCI. For individuals who do not have a clinical diagnosis of depression or anxiety, the findings from this review suggest that LTPA is safe and may help improve mood/perceived symptoms of depression and anxiety or at least not make them worse. However, the findings from the observational studies reinforce that there is a lack of research among people with SCI with a clinical diagnosis of an anxiety or depression disorder.

Differences in the type and dosage of LTPA intervention as well as the variance in sample size and participant demographics most likely contribute to the conflicting findings across studies. Future studies and further analyses that attempt to control for type of LTPA intervention and dosage and/or SCI demographics such as age, gender, time post injury, and SCI location, and severity are needed to further explore the relationships between LTPA and anxiety and depression. Overall, there is still lots to learn about the role of LTPA on anxiety and depression in individuals with SCI. More research is needed with anxiety and/or depression as the primary outcome, that consider a global perspective and/or cultural/geographical considerations, that look at sex and/or gender differences, and that target individuals with clinical diagnoses of anxiety and depression at baseline. To inform clinical application, it would be helpful if future studies include detailed reports on intervention dosage and proposed mechanisms of effectiveness as well as measures at follow-up timepoints.

Conclusion

There is level 1a evidence from 6 RCTs - and support from level 4 evidence from 3 pre-post studies and level 5 evidence from 7 observational studies - that participation in LTPA can reduce symptoms of depression among persons with SCI. However, there is level 1b evidence from 1 RCT - along with level 4 and 5 evidence from 6 pre-post studies and 3 observational studies - showing no significant effect/relationship between LTPA and depressive symptoms among persons with SCI.

There is level 1a evidence from 2 RCTs supported by another lower level RCT that LTPA intervention had no significant effect on symptoms of anxiety among persons with SCI. There is level 4 evidence from 2 pre-post studies, supported by level 5 evidence of 4 observational studies, that LTPA participation is related to lower symptoms of anxiety for persons with SCI.

3.2 Quality of Life

Individuals with SCI tend to report poorer quality of life (QOL) than people without a disability. Leisure time physical activity (LTPA), or physical activity that one chooses to do in their spare time, improves the QOL among many populations, including persons with SCI (Tomasone et al., 2013). LTPA can influence both objective QOL ("what I have"; the congruency between one's achievements and one's expectations) (Dijkers, 2003) and subjective QOL ("what I think or feel about what I have"; one's thoughts and feelings what one's achievements meeting one's expectations) (Dijkers, 2003) for persons with SCI. Notably, both objective and subjective QOL are dynamic and subject to change following participation in LTPA. The goal for this section is to examine if participation in LTPA is associated with objective and/or subjective QOL among persons with SCI.

Table 2. Physical Activity for Quality of Life Following SCI

Author Year Country Research Design PEDro Score Total Sample Size	**Methods**	**Outcome**
	Population: 35 individuals- 30 males and 5 females; chronic SCI; 8 AIS C and 27 AIS D; level of injury: C2-T10. mean	**Subjective QOL** 1. Immediately following the training program, 28 out of the

Alexeeva et al. 2011 USA RCT PEDro=7 N=35	age= 38.5y; median years post injury= 4y **Intervention**: Patients participated in a 13-week training program, with three 1hr sessions per week. The PT group is a structured rehab program individualized for each participant. The TRK group consisted of body weight supported ambulation on a fixed track. The TM group involved body weight supported ambulation on a treadmill. **Outcome Measures**: Quality-of-life survey (incorporated a subset of items from two existing questionnaires: Satisfaction with Abilities and Well-Being Scale [SAWS] and the SF-36 Short-Form Health Survey [SF-36]).	35 study participants (i.e. 80%) reported better satisfaction with abilities and well-being (SAWS). 2. The degree of score improvement (where a lower value reflects higher satisfaction) was roughly constant across training groups, and the overall effect across groups was significant (p=0.03). 3. These improvements were retained at the 1-month follow-up evaluation (p>0.05). **Objective QOL** 1. No other significant between- or within-group differences on QOL measures were observed following training (p>0.05).
Bailey et al. 2020 UK RCT Crossover PEDro=6 $N_{Initial}$=18, N_{Final}=14	**Population:** Mean age: 51±9yr; Gender: males=6, females=8; Injury etiology: traumatic=11, non-traumatic=3; Level of injury: T6-12=8, L1-5=5, Post-polio syndrome=1; Level of severity: complete=4, incomplete=10. **Intervention:** Individuals were allocated to 2, 5.5hr experimental conditions in random order. One condition was uninterrupted sedentary time (SED) where individuals remained seated and sedentary throughout in a wheelchair. The other condition was sedentary time interrupted with physical activity breaks (SED-ACT) where individuals performed physical activity for 2 min every 20 min at ~70 rpm using the Lode Angio arm ergometer with fifteen breaks. Sedentary behaviours included reading, writing, using a laptop computer or a tablet. Standardized breakfast and lunch meals were consumed during each condition. Questionnaires were	**Objective QOL** 1. Positive affect was significantly higher in SED-ACT than SED (P=0.001). **Subjective QOL** 1. There were no significant differences between conditions for score on the National Well-being Measurement, and the Warwick Edinburgh Mental Well-Being Scale (p>0.05).

	completed before and after each experimental condition. **Outcome Measures**: National Well-being Measurement, Warwick Edinburgh Mental Well-Being Scale, Schwarzer and Renner Physical Exercise Self-Efficacy Scale	
Chemtob et al. 2019 Canada RCT PEDro=9 $N_{(start)}$=24 $N_{(end)}$=22	**Population:** Age=51.64±12.13yr.; Gender: males=16, females=8; Level of injury: paraplegia=24, quadriplegia=0; Level of severity: Not reported; Time since injury=15.45±12.85yr. **Intervention:** Participants were randomized to either an intervention group which received one, 1-hour counselling session per week for 8 weeks via online video chat, or a control group who continued their regular routine. **Outcome Measures:** Life Satisfaction Questionnaire-11 (LSQ-11), Meaning Questionnaire (MQ).	**Subjective QOL** 1. The intervention group reported slightly greater levels in LSQ-11 scores at 6 weeks and moderately greater levels in LSQ-11 scores at 10 weeks. 2. The intervention group reported greater scores in the MQ than the control group.
Kemp et al. 2011 USA RCT PEDro=1 N=58	**Population:** individuals with SCI paraplegia who were also experiencing shoulder pain; Mean age: 45yr; Gender: not reported; Level of injury: Mean time post-injury: 20.1yr. **Intervention:** Participants were randomized to either an exercise treatment or a control group. Participants in the treatment group participated in a 12wk, at-home, exercise and movement optimization program designed to strengthen shoulder muscles and modify movements related to upper extremity weight bearing. **Outcome Measures:** Subjective Quality of Life Scale.	**Subjective QOL** 1. In the experimental group, there were significant improvements in QOL scores ($p=0.001$). 2. No significant changes in QOL scores were observed for the control group from baseline to post-intervention ($p>0.05$).
Latimer et al. 2005	**Population:** *Exercise Group* (n=13): Mean age: 37.54yr; Gender: males=9, females=4; Level of injury: paraplegia=6, tetraplegia=7; Level of severity: incomplete=8, complete=5; Mean time since injury: 9.23yr; *Control Group* (n=10): Mean age: 43.30yr;	**Objective & Subjective QOL Interaction** 1. At baseline, there was a strong positive relationship between stress and depression for both conditions ($p<0.05$).

Canada Secondary analysis of RCT (Hicks et al., 2003) PEDro=8 N=23	Gender: males=8, females=2; Level of injury: paraplegia=6, tetraplegia=4; Level of severity: incomplete=5, complete=5; Mean time since injury: 15.70yr. **Intervention:** Experimental group participated in a progressive exercise training program twice weekly for 9mo on alternative day's 90-120 min starting with warm up, upper extremity stretching, and 15 to 30 min of aerobic training. As the rate of perceived exertion decreased, workload was increased. Some resistance training took place. **Outcome Measures:** Perceived Stress Scale (PSS), Centre for Epidemiological Studies Depression Scale (CES-D), seven items from the 11-item Perceived Quality of Life Scale (PQOL).	2. At six months, the stress-depression association was no longer significant for the exercise group ($p > .05$). 3. The strong stress-depression relationship demonstrated at baseline was maintained across the three- and six-month measurement points for the control group ($p<0.05$). 4. At baseline, there was a strong negative relationship between stress and perceived quality of life for both conditions ($p < .05$). 5. At three- and six-month, the stress-perceived quality of life relationship was no longer significant for participants in the exercise condition ($p>0.05$). 6. The stress-perceived quality of life relationship remained significant across all three time points for the control condition ($p<0.05$).
Madhus mita et al. 2019 India RCT PEDro=8 N=124	**Population:** SCI; Integrated Yoga and Physiotherapy (IYP) Group: Mean age: 33.97yr; Gender: males=54, females=8; Level of injury: incomplete, (AIS)-C and (AIS)-D; Time since injury: >6mo Control Group: Mean age: 32.84yr; Gender: males=53, females=9; incomplete, (AIS)-C and (AIS)-D; Time post-injury: >6mo **Intervention:** Participants in the IYP group received 75 min (6 days/wk) of an integrated yoga intervention for 1 mo. The control group received physiotherapy only. Physiotherapy session for both groups lasted for 60min/day and 6 days/wk for 1mo **Outcome Measures:** Medically-Based Emotional Distress Scale (MEDS); Quality of Life Index Spinal Cord Injury - Version III (SCI-QOL index)	**Objective QOL** 1. Participants showed significant improvements in MEDS ($p<0.001$) compared to the control group. **Subjective QOL** 1. Participants showed significant improvements in SCI-QOL Index ($p<0.001$) compared to the control group.
Mulroy et al. 2011	**Population:** SCI; Intervention Group: Mean age: 47yr; Gender: males31;	**Objective QOL**

USA RCT PEDro=7 N_{Inital}=80, N_{Final}=52	females=9; Level of injury: Paraplegia=40; Injury severity: AIS A=25, AIS B=9, AIS C=3, AIS D=1, Unknown=2; Mean time post-injury: 17.9yr. Control Group: Mean age: 47yr; Gender: males=26, females=14; Level of injury: Paraplegia=40; Injury severity: AIS A=25, AIS B=5, AIS C=5, AIS D=1, Uknown=4; Mean time post-injury: 22.3yr. **Intervention:** Participants were randomly allocated to either the exercise/movement optimization group or the attention control group. The exercise/movement optimization intervention consisted of a 12-wk home-based program of shoulder strengthening and stretching exercises, along with recommendations on how to optimize the movement technique of transfers, raises, and wheelchair propulsion. The attention control group viewed a 1-h educational video. Outcome measures were assessed at baseline, at the end of the 12-week intervention, and at 4 weeks after the end of the intervention. **Outcome Measures:** 36-Item Short-Form Health Survey (SF-36), Subjective Quality of Life Scale (SQOL).	1. All SF-36 subscales, except for general health and vitality, improved significantly for the exercise/movement optimization group ($p<0.05$), and showed no change for the attention control group. 2. Both groups maintained their levels from post-intervention to 4 weeks follow-up with no group x time interactions effects. **Subjective QOL** 1. Overall SQOL scores increased significantly following the intervention for the exercise/movement optimization group ($p=0.04$), but were unchanged for the attention control group post intervention.
Nightingale et al. 2018 U.K. RCT PEDro=7 N=21	**Population:** Mean age=47±8yr; Gender: males=15, females=6; Time since injury: 16±11yr; Level of injury: T4 and below; Severity of injury: not reported. **Intervention:** Participants were randomly assigned to a home-based moderate-intensity upper-body exercise intervention (n=13) or a lifestyle maintenance control group (n=8) for 6 weeks. Outcome measures were assessed at baseline and follow-up. **Outcome Measures**: Physical and mental component scores (PCS and MCS)	**Objective QOL** 1. The exercise intervention group significantly improved PCS and MCS ($p=0.017$) outcomes in relation to controls.

Nooijen et al. 2017 The Netherlands RCT PEDro=6 $N_{Initial}$=45; N_{Final}=39	**Population**: *Intervention group*: Mean age: 44yr; Gender: males=17, females=3; Level of injury: Tetraplegia=7, Paraplegia (13); Mean time post injury: 139 days. *Control group*: Mean age: 44yr; Gender: males=16, females=3; Level of injury: Tetraplegia=6, Paraplegia=13; Mean time post injury: 161 days. **Intervention**: Intervention group: A behavioral intervention promoting physical activity, involving 13 individual sessions delivered by a coach trained in motivational interviewing, beginning 2mo before and ending 6mo after discharge from inpatient rehabilitation. Control group: Regular rehabilitation. **Outcome Measures**: 36-item Short Form Health Survey questionnaire (SF-36).	**Objective QOL** 1. No significant differences in QOL were observed (p>0.05).
Piira et al. 2020 Norway Secondary Analysis of Two RCTs combined PEDro=7 $N_{Initial}$=44, N_{Final}=37	**Population:** Chronic motor incomplete SCI; *Intervention Group (n=16):* Mean age: 50yr; Gender: males=10, females=6; Level of injury: cervical=7, thoracic=6, lumber=3; Injury severity: AIS C=4, AIS D=12; Cause of injury: traumatic: n=10, non-traumatic: n=6; Mean time post-injury: 14.6yr. *Control Group (n=21):* Mean age: 49yr; Gender: males=13, females=8; Level of injury: cervical=10, thoracic=10, lumbar=1; Injury severity: AIS C (n=8), AIS D (n=13); Cause of injury: traumatic: n=11, non-traumatic: n=10; Mean time post-injury: 11.1yr. **Intervention:** Data of this study was combined from two independent single-blinded RCTs. Intervention Group: Intervention consisted of 60 training days of BWSLT, either with manual or robotic assistance 60–90min per day, 3–5 days per wk over 6mo. Participants were suspended in a body-weight support system with treadmills (Study 1) or the Lokomat gait training robot (Study 2). A physical therapist supervised three to	**Objective QOL** 1. Health related quality of life (HRQOL) did not improve significantly in the intervention group compared to the control group (SF-36; p>0.05).

	five staff members (Study 1) or controlled the robotic device (Study 2) Control Group: usual care. **Outcome Measures**: 36-Item Short-Form Health Status Survey (SF-36)	
Qi et al. 2018 China RCT PEDro=5 N=40	**Population:** *Intervention Group*: Mean age: 38.3yr; Gender: males=15, females=5; Injury severity: ASIA A=7, ASIA B=2, ASIA C=3, ASIA D=8; Time post-injury: 5.61mo. *Control Group*: Mean age: 43.05yr; Gender: males=16, females=4; Level of injury: ASIA A=8, ASIA B=2, ASIA C=2, ASIA D=8; Time post-injury: 5.11mo. **Intervention:** In addition to normal rehabilitation intervention, participants in the intervention group received wheelchair Tai Chi (WCTC) training (two 30min sessions/d, 5d/wk for 6wk. The program consisted of three parts: ● A 5-min warm-up session ● WCTC movements that encompassed 16 easy-to-learn and easy-to-perform forms ● A 5-min cool-down session. Control Group: Normal rehabilitation intervention only. **Outcome Measures:** short version of the World Health Organization's Quality of Life Instrument (WHOQOL-BREF).	**Objective QOL** 1. Compared with the control group, the psychological domain of QOL improved significantly in the WCTC group (time by group interaction, $p<0.05$).
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.	**Objective QOL** 1. When compared to control group, the intervention group showed statistically significant improvements in the following: • Health promoting lifestyle (HPLP- II, $p<0.001$); • Stress management techniques, perceived stress (HPLP-II subscale, $p=0.001$).

	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); all at baseline and post-study.	
Chen et al. 2009 Taiwan PCT N=30	**Population:** SCI; Mean age: 48.2yr; Gender: males=14, females=16; Level of injury: ASIA C and D at the spinal segments L1 to S2. **Intervention:** The experimental group underwent therapy with a virtual-reality-based exercise bike. Participants were asked to sit comfortably on the exercise bike and then to pedal at their preferred speed for as long as they could. The control group underwent the therapy without virtual-reality equipment. **Outcome Measures:** Activation–Deactivation Adjective Check List (AD-ACL)	**Objective QOL** 1. The experimental group showed significantly better scores on AD-ACL calmness (p=0.042) and tension (p=0.036) compared to the control group following the intervention.
Daniel et al. 2005 India PCT N=50	**Population:** Patients with paraplegia; *Experimental Group:* Mean age: 33.40yr; Gender: males=21, females=4; Time post injury: <3mo=4, >3mo=21. *Control Group*: Mean age: 37.24yr; Gender: males=18, females=7; Time post injury:<3mo=17, >3mo=8. **Intervention:** The experimental group participated in 1 h-long leisure group sessions 3x/wk; the control group did not participate in intervention sessions. **Outcome Measures:** World Health Organization Quality of Life Scale – Brief (WHO QOL – BREF), Leisure Satisfaction Scale (LSS).	**Objective QOL** 1. Significant improvements were observed in all domains of quality of life in the experimental group compared to the control group (p<0.01), except for social relationships.
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-	**Objective QOL** 1. Participants' overall quality of life improved significantly from baseline (p<0.05). **Subjective QOL** 2. Participants showed a significant improvement in self-

	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:** Rosenberg Self-Esteem Scale (RSS), World Health Organization Quality of Life Scale – BREF (WHOQOL-BREF).	esteem compared to baseline ($p<0.001$).
Alajam et al. 2020 USA Pre-Post $N_{Initial}$=15, N_{Final}=11	**Population:** SCI; Mean age= 38±10yr; Gender: males=8, females=3; Level of injury: T3-L1; Mean time post-injury: 8.72±10.40yr. **Intervention:** Participants received walking training, 3 sessions/wk for 8wk. Participants were trained on a treadmill using a novel assistive gait training device consisting of a thigh brace attached to a pulley cable designed to assist with leg flexion. **Outcome Measure:** Short form-36 Health Survey (SF-36).	**Objective QOL** 1. The overall score of SF-36 significantly increased after training ($p<0.01$).
Allin et al. 2020 Canada Pre-Post $N_{initial}$=11 N_{final}=10	**Population:** Age=43±8yr.; Gender: males=4, females=7; Level of injury: paraplegia=5, tetraplegia=3, not reported=3; Level of severity: Not reported; Time since injury=20±12yr. **Intervention:** Participants took part in a self-paced, six-session self-management program guided by a trained peer health coach. The program lasted between 35-88 days with a total of 6 coaching sessions. **Outcome Measures:** Spinal Cord Injury Quality of Life Resilience Scale [SCI-QOL-R])	**Subjective QOL** 1. SCI-QOL-R score improved and trended towards significance ($p=0.08$).

Barbin & Ninot. 2008 France Pre-Post N=10	**Population:** SCI; Mean age: 32.1yr; Gender: males=7, females=3; Level of injury: cervical=3, lumber=2, thoracic=5; Mean time post-injury: 5.1yr. **Intervention:** Participants took part in a 1-wk adapted skiing program. The skiing program was a group activity including 30 participants (10 participants with spinal cord injury and 20 specialized physical educators) over a period of 5 days, 5 h/day. **Outcome Measures:** Physical Self Inventory.	**Objective QOL** 1. After the skiing program, participants demonstrated significant improvements in global self-esteem (p=0.007), physical self-worth (p<0.001) and three subdomains (physical condition: p=0.008; sport competence: p=0.004; attractive body: p=0.001) 2. The physical strength dimension of the Physical Self-Esteem inventory did not change significantly from pre-skiing to post-skiing.
Bochkezanian et al. 2018 Australia Pre-Post N=5	**Population:** Individuals with chronic SCI; Mean age: 41.2yr; Gender: males=4, females=1; Injury severity: AIS A=2, AIS B =2, AIS D=1; Mean time post-injury: 3.2yr. **Intervention:** Participants completed five 10-repetition sets of high-intensity knee extension NMES strength training sessions for 12wk in both quadricep muscles. **Outcome Measures:** QOL index SCI version III.	**Subjective QOL** 1. QOL showed a near-significant improvement in the health and functioning domain (p=0.07)
Chen et al. 2006 USA Pre-Post N=16	**Population**: Mean age: 43.8yr; Gender: males=9, females=7; Level of injury: tetraplegia=25%, paraplegia=75%; Severity of injury: ASIA A=56%, ASIA C=19%, ASIA D=25%; Cause of injury: traumatic=93.75%, non-traumatic=6.25%. **Intervention**: 12wk of a weight management program (e.g., nutrition, exercise, behaviour modification training) + 1-30-min exercise session/wk for 6wk. **Outcome Measures**: General Well-Being Schedule.	**Objective QOL** 1. Although there were small increases in general well-being schedule scores from baseline to 12 weeks and baseline to 24 weeks, they did not reach statistical significance (p=0.12).
Curtis et al. 2015 Canada Pre-Post N=11	**Population:** Mean age=48.4±15yr; Gender: males=1, females=10; Time since injury=157.4±191.8mo; Level of injury: complete=3, incomplete=6; unknown=1, not reported=1; Severity of	**Subjective QOL** 1. No significant differences between baseline and exit scores for the PANAS (p>0.05).

	injury: tetraplegia=2, paraplegia=6, unknown=1, not reported=2. **Intervention:** Participants took part in an 8-wk modified yoga program with assessments taken at baseline and post-intervention. **Outcome Measures:** Positive and Negative Affect Scale (PANAS)	
Ditor et al. 2003 Canada Pre-Post N=7	**Population**: Mean age: 43.3yr; Gender: males=5, females=2; Time post injury: 3-23yr. **Intervention**: Patients who previously took part in a 9mo exercise training program were given 3mo (2 sessions/wk) of continued supervised exercise training in a laboratory setting. **Outcome Measures**: 11-item Perceived Quality of Life Scale (PQOL) with four additional SCI-relevant items, Perceived Stress Scale (PSS).	**Objective QOL** 1. At 3-month follow-up, a trend was found for increased stress ($p=0.12$). **Subjective QOL** 1. At 3-month follow-up, a decrease in PQOL was found ($p<0.05$).
Effing et al. 2006 The Netherlands Pre-Post N=3	**Population:** Chronic incomplete SCI; Age (range): 45-51yr; Gender: 3 males; Severity of injury: AISA C (75%), ASIA D (25%); Time post-injury (range): 29-168mo. **Intervention:** Body weight supported treadmill training 5d/wk for 30 min/session for 12wk personalized to physical abilities. **Outcome Measures:** Schedule for the Evaluation of Individual Quality of Life (SEIQOL). Collected at baseline, 6wk – treatment, 12wk – wash-out, 6wk – follow-up, 6 mo.	**Subjective QOL** 1. Participant 1: • Showed significant improvement in perceived QOL during the intervention phase ($P<0.05$) • Perceived QOL did not change significantly between the baseline and the wash-out phase or after the follow-up ($P>0.05$) 2. Participant 2: • Judged his QOL as unchanged during the intervention phase ($P>0.05$), and diminished during the wash-out phase ($P<0.05$). • At the end of the follow-up, the subject's perception of his QOL had improved, reaching the baseline level. 3. Participant 3

		• During the baseline, intervention, and wash-out phases, participant 3 judged his QOL as not changed (P>0.05) but as improved after the follow-up.
Fundaro et al. 2018 Italy Pre-Post N=39	**Population:** SCI: n=21; Parkinson's Disease (PD): n=10; Stroke Event: n=8; Age range: 33 to 79yr; Gender: males=27, females=12; Level of injury (SCI): paraplegia (n=4), paraparesis (n=11), quadriplegia (n=1) quadriparesis (n=5). **Intervention:** Participants underwent robot gait training with Lokomat. The training period lasted for 4wk, with 30min session carried out 3x/wk. **Outcome Measures:** Psychosocial Impact of Assistive Device (PIADS)	**Subjective QOL** 1. PIADS total and subscale scores significantly improved for all participants from pre- to post-intervention (p<0.01; no between-group differences were observed (p>0.05).
Hicks et al. 2005 Canada Pre-Post N=14	**Population:** Chronic incomplete SCI: N=14; Tetraplegic=11, Paraplegic=3; Gender: males=11, females=3; Age range=20-53yr; Mean time post injury=7.4yr; ASIA: B=2, C=12. **Intervention:** Body weight supported treadmill training (BWSTT) – up to 45 min, 3x/week, 144 sessions (12mo). **Outcome Measures:** Satisfaction with Life Scale (SWLS), SF-36	**Objective QOL** 1. Increased physical function satisfaction (p<0.05) after BWSTT. **Subjective QOL** 1. Increased life satisfaction (p<0.05) after BWSTT.
Kennedy et al. 2006 United Kingdom Pre-Post N=35	**Population:** Gender: males=30, females=5; Age: 18-61yr, Level of injury: paraplegia=20, tetraplegia=15. **Intervention:** 'Back-Up Trust' sports participation program: 1wk participation in single or multi-activity course in an integrated, residential environment. Activities include skiing, horseback riding, waterskiing, canoeing, rappelling and gliding. Questionnaires were completed at baseline and end of 1wk activity courses **Outcome Measures:** Life Satisfaction Questionnaire (LSQ)	**Subjective QoL** 1. A significant difference was demonstrated for life satisfaction as a whole (Z = 2.40, p=.016) and satisfaction with leisure between the start and end of the course (Z=2.69, p=.007).

Protas et al. 2001 USA Pre-Post N=3	**Population:** 3 males; age 34-48yr; Participant diagnosis was AIS C and D; T8-T12 lesion level; 2-13yr post-injury. **Intervention**: BWSTT: 20 min, 5x/wk, for 12 wks. **Outcome measures:** Center Positive and Negative Affect Schedule (PANAS), Life Satisfaction Index—A (LSIA)	**Subjective QOL** 1. Life satisfaction, and positive and negative affect did not change significantly for these 3 participants during training (ps>0.05).
Radomski et al. 2011 USA Pre-Post N_{Inital}=13, N_{Final}=10	**Population:** Median age: 33yr; Gender: males=6, females=4; Median time post injury:8.5yr. **Intervention:** Participants completed a 12wk exercise and education program, which involved individualized diet and exercise recommendations, once weekly group nutrition and exercise education classes, and twice weekly exercise sessions (group and individual). **Outcome Measures:** General Well-Being Schedule	**Objective QOL** 1. General well-being increased from a median of 72.0 to 85.5 (P = .059), a pre-post change to positive well-being.
Semerjian et al. 2005 USA Pre-Post N=12	**Population:** Mean age: 34yr; Gender: males=8 males, females=4; Level of injury: Tetraplegia=7, Paraplegia=5; Time post injury: 1-30yr. **Intervention**: 10wk individualized exercise program, 2d/wk, using the Bowflex Versatrainer, the Active-Passive Trainer, the EasyStand 6000 Glider, and the Body Weight Support System treadmill trainer (BWST). **Outcome Measures**: Quality of Life Index-Spinal Cord Injury Version III (QLI-SCI III) – 4 subscales: Health & Functioning, Psychological, Social & Economic and Family; the Body Satisfaction Questionnaire (BSQ); Semi-structured interview; Field notes taken during each session; Questionnaires done pre & post intervention, interview done post intervention.	**Subjective QOL** 1. QOL: ● The overall QOL (p<0.001), as well as the Health and Functioning (p<0.001), Psychological (p<0.05), and Social and Economic (p<0.05) subscales improved significantly post-intervention. ● No significant changes in the Family subscale scores were observed. 2. Body Satisfaction: ● Perceived body functioning (p<0.001) and body attractiveness (p<0.05) increased significantly post intervention.

Sharif et al. 2014 Canada Pre-Post N=6	**Population:** Gender: males=3, females=3; Level of injury C5 to L4; All AIS D; mean age= 60.5 ± 13.2yr; Mean time post injury: 9.3 ± 12.0yr. **Intervention:** The exercise protocol consisted of 12wk of FES-ambulation, with the RT600 (Restorative Therapies, Baltimore, MD), at a frequency of 3x/wk. **Outcome Measures**: HRQOL was assessed via the Short Form-36, Perceived Stress Scale (PSS)	**Objective QOL** 1. Participants showed a decrease in the Short Form-36 pain score and an increase in the overall mental health score. 2. However, no significant changes were detected in perceived stress.
Shem et al. 2016 USA Pre-Post $N_{Initial}$=26, N_{Final}=10	**Population:** SCI; Mean age: 49.8±13.0yr; Gender: males=14, females=12; Level of injury: tetraplegic=16, Level of injury: paraplegic=6, unknown=4, Mean time post-injury: 25.1yr. **Intervention:** Participants completed a 12-week seated Tai Chi course consisting of weekly sessions (one 90-min session/wk). **Outcome Measures:** emotional sense of well-being (EWB), mental distraction (MD), physical sense of well-being (PWB), and sense of spiritual connection (SC,)	**Objective QOL** 1. No significant between-group differences in the outcome measures were observed.
Sliwinski et al. 2020 USA Secondary Analysis $N_{Initial}$=22; N_{Final}=18	**Population:** Level of injury: C2-L5 (cervical injury=52%, thoracic injury=37%, lumbar injury=10%); Mean time post injury: 8.6yr. **Intervention**: An 8-week community exercise program (one 4 hr session/wk) that includes a four-station circuit of resistance exercises, aerobic conditioning, trunk stability, and health education. **Outcome Measures**: Life Satisfaction Questionnaire-9 (LiSAT-9).	**Subjective QOL** **1.** QOL improved significantly after the intervention ($p<0.001$).
Anneken et al. 2010 Germany Observational N=277	**Population:** Mean age: 41.7 ± 12.7yrs; Gender: 219 males, 58 females; Level of injury: Paraplegia (78.3%); Severity of injury: Complete (62.9%); Cause of injury: traumatic (79%), non-traumatic (21%); **No Intervention:** Questionnaire	**Objective QOL** 1. The most prominent differences between the physically active and physically inactive individuals occurred in the single scales of physical domain (physical capacity in

	Outcome Measures: QOL Feedback	everyday life, physical activity, and mobility); all p<0.001. In the single scales of the psychological domain, prominent differences were found in remedial exercises, energy, and self-confidence; all p<0.001.
Bassett & Ginis 2009 Canada Observational N=50	**Population:** Mean age: 42yr; Gender: Males=50; Level of injury: paraplegia=25, tetraplegia=25; Level of severity: AIS A=20, AIS B-D=30; Time since injury: ≥1yr. **No Intervention**: Participants reported their functional and appearance body image, perceived body image on quality of life (QOL), and leisure-time physical activity performed over the previous 3 days. **Outcome Measures**: Body image: The Adult Body Satisfaction Questionnaire (ABSQ), perception of body image on quality of life (QOL): 7-point scale, leisure time physical activity: Physical Activity Recall Assessment for People with SCI (PARA-SCI)	**Subjective QOL** 1. Linear regression found a significant LTPA x body image impact on QOL (p<0.05). • Among individuals who reported a negative effect of body image on QOL, those who engaged in LTPA were less satisfied with their physical function than those who did not. • Those who did not perceive their body image to negatively impact QOL, there was generally no difference in functional body image between those who engaged in LTPA and those who did not.
Dallmeijer and van der Woude 2001 The Netherlands Observational N=37	**Population:** Mean age: 36.5yr; Gender: males=37, females=0; Level of injury: high tetraplegia (motor complete; C5 ± C6, n=10), low tetraplegia (motor complete, C6/7 ± C8, n=9), motor incomplete tetraplegia (n=7), paraplegia (n=11); Mean time since injury: 4.3yr. **No Intervention:** Participants performed a maximal wheelchair exercise test in the laboratory and were asked to fill out the SIP68 questionnaire. **Outcome Measures:** Short version of the Sickness Impact Profile (SIP68), including a physical (SOM), psychological (PSY) and social subscore (SOC). Endurance capacity	**Objective QOL** 1. Total SIP68-score and SOM were significantly different between lesion groups, showing higher values in the high- and low-tetraplegia group (p<0.05). 2. There were no differences between lesion groups for PSY and SOC subscores (ps>0.05). 3. Significant negative correlations were found for VO_{2peak} and PO_{max} with SIP68 and SOM and SOC (ps<0.05), indicating that a higher endurance capacity was associated with a better functional status; no significant

	(maximal power output (PO_{max}) and peak oxygen uptake (VO_{2peak}).	relationship was found with PSY (p>0.05). 4. After correction for lesion level, 22% of the variance of SIP68, 8% of the variance of SOM, and 30% of the variance of SOC was explained by PO_{max} or $VO2_{peak}$ (P<0.001).
Garshick et al. 2016 USA Observational N=347	**Population:** SCI: *with Dyspnea:* Mean age: 45.0±16.2yr; Gender: males=87; females=17; Median time since injury: 10.0yr; cervical motor complete and AIS C=13, high thoracic motor complete and AIS C=27, other motor complete and AIS C=27, AIS D=32. W*ithout Dyspnea:* Mean age: 44.9±15.2yr; Gender: males=206; females=37; Median time since injury: 9.0yr; cervical motor complete and AIS C=38, high thoracic motor complete and AIS C=41, other motor complete and AIS C=105, AIS D=52. **No Intervention:** Participants filled out a questionnaire survey by interview (89%) or self-completed (11%). **Outcome Measures:** Satisfaction with life scale (SWLS), Physical Activity Recall Assessment for People with SCI.	**Subjective QOL**. 1. Using a multivariate model adjusting for covariates, it was found that there was a significant linear trend between greater SWLS and more time spent away from home (p=0.0002), as well as participation in sports (p=0.010).
Gernigon et al. 2015 France Observational N=18	**Population:** *Participants (n=10):* Mean age: 33.8±19.8yr; Gender: males=7, females=3; Level of injury: paraplegia=7, tetraplegia=3. *Non-participants (n=8):* Mean age: 40.5±15.4yr; Gender: males=6, females=2; paraplegia=2, tetraplegia=6. **No Intervention:** Individuals were assigned in either the participants group or the non-participants group depending on whether they engaged or not in Adapted Physical Activity (APA) programs. **Outcome Measures:** Approach and Avoidance Questionnaire for Sport and Physical Education (AAQSPE),	**Subjective QOL** 1. Non-participants had significantly lower scores of physical self-worth than participants (p<0.05). 2. There was no significant between-group difference in perceived physical condition, physical strength, body attractiveness, sport competence, and global self-esteem (p>0.05).

	Physical Self-Perception Profile (PSPP).	
Greenwood et al. 1990 USA Observational N=127	**Population:** Tennis Group: Mean age: 32.60yr; Gender: males=77, females=10; Time since injury: ≥2yr; Nontennis Group: Mean age: 35.40yr; Gender: males=32, females=8; Time since injury: ≥2yr. **No Intervention:** Questionnaires. The tennis participants were recruited from the 7 Southwest National Wheelchair Tennis Championships. The nontennis group participants had the physical capabilities necessary to compete in wheelchair tennis but were not actively involved in an exercise program or a competitive sport. **Outcome Measures:** Two self-efficacy scales assessing participants' self-efficacy expectations toward playing tennis and performing daily wheelchair mobility task, Profile of Mood States (POMS).	**Objective QOL** 1. The tennis group showed significantly better scores on all six POMS measures (i.e., tension, depression, vigor, fatigue, confusion, anger), compared to the nontennis group (ps<0.001).. 2. For the wheelchair nontennis participants, wheelchair mobility self-efficacy significantly correlated with each of the POMS subscales except for depression (ps<0.001).
Lannem et al. 2010 Norway Observational N=116	**Population:** *AIS A-B (n=47):* Mean age: 48yr; Gender: males=41, females=6; Level of injury: Tetraplegia=13, Paraplegia=34; Mean time since injury: 29yr. *AIS D (n=69):* Mean age: 48yr; Gender: males=56, females=13; Level of injury: Tetraplegia=35, Paraplegia=34; Mean time since injury: 18yr. **No intervention:** Participants completed a questionnaire pertaining to exercise status and exercise-related self-perceptions. Aerobic work capacity was tested using an arm ergometer for those with motor complete SCI. For those with incomplete SCI either arm or leg cranking was used. Participants who exercised at least once per week were categorized as "exercisers". **Outcome Measures:** Self-Perception in Exercise Questionnaire (SPEQ)	**Subjective QOL** 1. Exercisers with complete and incomplete SCI showed significant differences in SPEQ mastery compared to non-exercising participants (p=0.002 and p=0.012, respectively). Exercisers with complete lesions reported more positive exercise mastery and those with incomplete lesions reported more negative exercise mastery than non-exercising participants. 2. SPEQ fitness was significantly higher for exercisers with complete (p=0.016) and incomplete (p=0.004) SCI compared to similar non-exercisers. 3. For incomplete injury, exercise status (p=0.04) and exercise hours per week (p=0.007)

		contributed negatively to the variance in SPEQ mastery.
Loy et al. 2003 USA Observational N=178	**Population:** Mean age: 43.6yr; Gender: males=73.7%, females=26.3%; Level of injury: paraplegia=56.1%, tetraplegia=43.9%; Level of severity: incomplete=69.1%, complete=30.9%; Mean time since injury: 9.6yrs. **No Interventions:** Questionnaire. **Outcome Measures:** Recreation and Health Survey (RHS)- assessed general participant information, injury information, leisure activities over the last year, leisure identity, perceived freedom, favorite leisure activities, leisure and coping with SCI, social support, health beliefs, subjective well-being, and depression.	**Objective QOL** 1. The model proposed that: (a) leisure engagement has a direct influence on the adjustment of individuals with SCI and (b) leisure engagement has an indirect influence on adjustment to SCI through the promotion of social support. 2. Results from structural equation modeling confirmed that the leisure and SCI adjustment model was an "acceptable" fit to data; however, leisure engagement explained only 13% of the variance in the adjustment to SCI construct and 5% of the variance in the social support construct. 3. Diversity and intensity were significantly associated with depression, subjective well-being, and perceived health ($p<0.05$). 4. Frequency was significant associated with subjective well-being ($p<0.05$), and perceived health ($p<0.01$).
Manns & 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**. 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	**Subjective QOL** 1. There was no correlation between subjective quality of life scores and fitness/physical activity in individuals with paraplegia or quadriplegia ($p>0.05$).

	Handicap Assessment Reporting Technique (CHART).	
Mulroy et al. 2016 Canada Observational N=86	**Population:** Mean age: 37.4±16.2yr; Gender: males=77, females=9; Mean time since injury: 11.1±7.5yr. **No Intervention:** Analysis of those with traumatic SCI who use a manual wheelchair. Participants were telephoned and asked to recall their activities during an interview based on the Physical Activity Recall Assessment. **Outcome Measures:** Wheelchair propulsion (WCP), Leisure-time physical activity (LTPA), Wheelchair usage, Patient Health Questionnaire-2 (PHQ-2), Satisfaction with Life Scale (SWLS).	**Subjective QOL** 1. On average, participants felt slightly satisfied with life, with a mean score of 23.3±6.4 on the SWLS. 2. LTPA was the only significant predictor of SWLS (r=.321, P=. 003); persons who reported more LTPA also reported higher SWL
Paulsen et al. 1990 USA Observational N=54	**Population:** *Athletes (n=26):* Mean age: 26.9yr; Gender: males=26, females=0: Level of injury: unknown; Level of severity: unknown; Time since injury: ≥2yr; *Nonathletes (n=28*): Mean age: 26.1yr; Gender: males=28, females=0; Level of injury: unknown; Level of severity: unknown; Time since injury: ≥2yr **No Intervention:** Questionnaire. **Outcome Measures:** Profile of Mood States (POMS; six subscales: Anger, Confusion, Depression, Fatigue, Tension, and Vigor)	**Objective QOL** 1. No significant between-group differences on other POMS subscales were found (ps>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, 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 Spinal Cord Injury, UCLA	**Subjective QOL** 1. 31.2% of the participants scored 6 or higher on the UCLA Loneliness Scale indicating feeling lonely at least some of the time. 2. Significant correlations were found between leisure time physical activity (LTPA) and life satisfaction (p=0.02), LTPA and loneliness (p=0.05), and loneliness and life satisfaction (p<0.001).

	Loneliness Scale, Life Satisfaction Questionnaire (LSQ).	2. Loneliness significantly mediated the relationship between LTPA and life satisfaction. 3. Loneliness significantly and negatively related to LTPA ($p=0.04$) and life satisfaction significantly and negatively related to loneliness ($p<0.001$).
Stevens et al. 2008 USA Observational NI_{nitial}=73 N_{Final}=62	**Population:** Mean age: 35±10yr; Gender: males=32, females=30; Level of injury: Tetraplegia=23, Paraplegia=39; Level of severity: Complete=38, Incomplete=24, Mean time since injury: 9±9yr. **No Intervention:** Cross sectional study to examine relationship of physical activity and quality of life. **Outcome Measures:** The Quality of Well-Being Scale (QWB).	**Objective QOL** 1. Pearson product correlation coefficient analysis showed a strong positive association between level of physical activity and quality of life ($p<0.05$), indicating that participants who reported higher levels of physical activity had greater QOL. 2. More than half (56%) of the variation in quality of life was explained by differences in physical activity level.
Tasiemski and Brewer 2011 Poland Observational N=1034	**Population**: Mean age: 35.93yr; Gender: males=861, females=173; I Level of injury: paraplegia: 49.8%, tetraplegia: 50.2%; Mean time since injury: 9.78yr. **No Intervention:** Questionnaire. **Outcome Measures:** Sport participation (i.e., hours of sport participation per week before and after injury, sport discipline practiced before and after injury, opportunities to practice one's favorite sport after injury, reasons for sport participation after injury, barriers to sport participation after injury, best sport results after injury, and years of sport participation after injury), involvement in nonsport recreational activities before and after SCI, Athletic Identity Measurement Scale (AIMS), Life Satisfaction Questionnaire (LiSat-9), Hospital Anxiety and Depression Scale (HADS).	**Subjective QOL** 1. Being able to practice one's favorite sport after SCI was associated with higher levels of life satisfaction ($p<0.001$). 2. Team sport participants reported better life satisfaction ($p<0.01$), than individual sport participants did.

Tasiemski et al. 2005 Poland Observational N=985	**Population**: Mean age: 48.1yr; Gender: males=798, females=198; Level of injury: tetraplegia A=216, tetraplegia B=65, tetraplegia C=61, paraplegia A=535, paraplegia B=38, paraplegia C=70. Mean time since injury: 19.5yr. **No Intervention:** Questionnaire. **Outcome Measures:** Sports Participation Questionnaire, life satisfaction questionnaire (LSQ), Hospital Anxiety and Depression Scale (HADS).	**Subjective QOL** 1. Participants who were involved in sports or physical recreation demonstrated higher general life satisfaction, compared to those not participating in physical activities ($p<0.001$).

Discussion

Description of studies. Forty-eight (48) studies examined the relationship between LTPA and quality of life. Of the 48 included studies, 12 were RCT designs, 20 were pre-post designs and 16 were observational/correlational designs. The RCT and pre-post designs examined the impact of varied types of LTPA interventions on QOL outcomes. For example, LTPA included activities like yoga (Curtis et al., 2015; Madhusmita et al., 2019) and tai chi (Qi et al., 2018; Shem et al., 2016), upper extremity training (Mulroy et al., 2011; Nightingale et al., 2018), body weight supported treadmill training (Fundaro et al., 2018; Hicks et al., 2005; Piira et al., 2020), functional electrical stimulation (Sharif et al., 2014), exercise programs (De Oliveira et al., 2016; Sliwinski et al., 2020), and sports (skiing) (Barbin & Ninot, 2008). In addition, several interventions focused on counselling or coaching with the use of behaviour change techniques (Allin et al., 2020; Chemtob et al., 2019; Nooijen et al., 2017). The included studies were from several countries, including USA (n=16), Canada (n=12), Netherlands (n=3), Australia (n=2), France (n=2), Norway (n=2), Poland (n=2), Germany (n=1), Italy (n=1), UK (n=3), India (n=2), China (n=1), Taiwan (n=1). Notably, nearly all research has been conducted in high-income countries with very few studies from low- or middle-income countries.

Overview of objective vs. subjective QOL. In line with Dijkers (2003) model, both objective and subjective QOL are necessary for a comprehensive understanding of QOL. Initially the SCI field focused mainly on objective QOL (Noreau & Shephard, 1995), which led to a call for both objective and subjective assessments. In a subsequent review of this area, Tomasone et al. (2013) reported 67 objective QOL analyses vs. 43 subjective QOL analyses, highlighting that the field continued to focus on reporting the relationship between LTPA participation and objective QOL. However, the use of subjective QOL measures were beginning to become more prominent. In the current review, we report 38 analyses between objective QOL scale or subscales and LTPA, and 34 analyses between subjective QOL scale or subscales and LTPA. A notable difference between the studies included in

Tomasone et al. (2013) and the current review on QOL is that Tomasone et al. (2013) included measures assessing pain, fatigue, anxiety or depression - these were excluded from the current review as they are included in other SCIRE sections. Regardless, over the past decade, the field has begun to place equal focus on subjective QOL and its relationship with LTPA.

The LTPA and QOL relationship. Among the 38 analyses for objective QOL, the relationship between LTPA and objective QOL was significantly positive in 28 analyses, whereas 10 analyses showed no significant relationships. No analyses showed a significant negative relationship between a measure of objective QOL and LTPA participation. Among the 34 analyses for subjective QOL, the relationship between LTPA and subjective QOL was significantly positive in 17 analyses, whereas 3 analyses showed a significant negative relationship, and 13 analyses showed no significant relationships. Overall, participation in LTPA was found to be positively associated with both objective and subjective QOL among individuals with SCI, with very few studies showing a significant negative relationship and relatively few studies showing no significant relationship between LTPA and QOL. Presumably, the increase in achievements, abilities, and opportunities that result from engaging in LTPA increase the congruency (i.e., decrease the discrepancy) between one's achievements and expectations (increase objective QOL), and thus lead to a more positive cognitive or affective response to the level of congruency (increase subjective QOL). The relationship between LTPA and subjective QOL requires further unpacking, as the surge in analyses exploring this relationship is relatively recent and the findings remain uncertain (i.e., many studies report a non-significant relationship between LTPA and subjective QOL).

Despite the overall finding that participation in LTPA is positively associated with objective and subjective QOL among persons with SCI, some findings are also mixed. Specifically, both within a given study and across the review, the relationship between LTPA and QOL is sometimes positively significant and other times not significant. Within the same study, mixed findings are often reported between the objective and subjective QOL measures that are used. For example, both Alexeeva et al. (2011) and Bailey et al. (2020) report that the LTPA-QOL relationship is positive for objective QOL but non-significant for subjective QOL. This phenomenon likely occurs because objective and subjective QOL are two different constructs – following LTPA participation, a person with SCI may notice that their achievements are more in line with their expectations (i.e., objective QOL increases) but may not change their feelings about the congruency between their achievements and expectations (i.e., subjective QOL remains the same). Within a given study, it is also common to see two different QOL scales used to assess either objective or subjective QOL. For example, Sharif et al. (2014) used two different objective QOL measures and reported that the LTPA-QOL relationship was positively and negatively significant using two subscales of one measure (the Short Form-36) and non-significant using a second measure (the Perceived Stress

Scale). It is also common for studies that used different subscales within a single QOL measure to report mixed findings. For instance, in their RCT, Mulroy et al. (2011) found that all Short Form-36 subscales except for general health and vitality improved significantly in the group that participated in exercise compared to controls. The LTPA literature typically distinguishes between global QOL (i.e., one's overall life satisfaction or well-being) and three QOL domains: physical (i.e., pertaining to one's physical functioning, such as health status), psychological (i.e., pertaining to both one's emotional well-being and one's cognitive functioning), and social (i.e., pertaining to one's social roles and functioning, such as marital and occupational status). Differentiating between QOL domains was beyond the scope of the current chapter but readers are encouraged to refer to Tomasone et al. (2013) for a discussion about domain-specific differences in the LTPA-QOL relationship, which may account for the discrepancies between subscale findings in a given study. In addition, it is possible that participant characteristics, such as injury level and injury characteristics (Lannem et al., 2010; Manns & Chad, 1999), may influence the LTPA-QOL relationship, which may be why certain studies found insignificant relationships. Researchers should be mindful of demographic differences, as well as other potential moderators, when they consider the LTPA-QOL relationship within their studies. Finally, some of the studies may have been underpowered (due to small sample sizes) to detect significant differences in QOL following participation in LTPA. Case in point, participants in Chemtob and colleagues' (2019) RCT did not report significant differences in life satisfaction (a measure of subjective QOL) following an 8-week behavioural counselling intervention, yet there was a medium effect size change in life satisfaction in the experimental group; a larger sample may have produced a statistically significant effect. Collectively, the mixed findings within a study point to the complexity in the conceptualization and measurement of the LTPA-QOL relationship.

Moving forward, we recommend that researchers identify which QOL measures are most responsive to the effects of LTPA, including the intervention dose (i.e., duration, frequency, length) and type of LTPA intervention (i.e., sport, exercise, yoga). Heterogeneity in intervention dose and type precluded our ability to make conclusions about the influence of these variables on the LTPA-QOL relationships for the current review, but is an avenue for future research.

Interestingly, there are connections between the variables included in this SCIRE chapter with the LTPA-QOL relationship. For example, Sweet et al. (2013) that depression (covered in section 3.1) and functional independence (covered in section 4) were statistically significant mediators of the LTPA-QOL relationship. Santino and colleagues' (2020) analysis found that loneliness significantly mediated the relationship between LTPA and life satisfaction (i.e., subjective QOL). We recommend researchers continue to explore the mechanisms by which LTPA influences both objective and subjective QOL to further unpack the complexities in the relationship.

Conclusion

There is level 1a evidence from six RCTs - as well as support from two lower quality RCTs and 14 additional studies - that participation in LTPA Is effective for increasing objective QOL among persons with SCI.

There is level 1a evidence from three RCTs - as well as support from one lower quality RCT and 13 additional studies - that participation in LTPA is effective for increasing subjective QOL among persons with SCI.

4.0 Effects of Physical Activity on Participation-related Outcomes

In this chapter, we are operationalizing the concept of (community/social) participation as involvement in life situations, in line with the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) (WHO, 2001). These life situations are often tied to "activities", another dimension of the ICF. Participation in these life situations and activities can then range between daily activities (e.g., preparing a meal) to leisure and social activities (e.g., meeting with friends). The evaluations/ratings of participation can be conceptualized as person-perceived participation (e.g., a person's own judgement of their level of participation in an activity) or society-perceived participation (e.g., a person's participation ability is judged against a social standard of "normal" participation) (Noreau et al., 2005). This section examines the evidence on the relationship between LTPA and participation in daily and social activities from studies that have assessed person-perceived or society-perceived participation. We do not explicitly separate the type of participation but rather provide an overview of the LTPA-participation relationship.

Table 3. Physical activity and participation-related outcomes following SCI

Author Year Country Research Design PEDro Score Total Sample Size	**Methods**	**Outcome**
Chemtob et al. 2019 Canada RCT PEDro=9	**Population:** Age=51.64±12.13yr.; Gender: males=16, females=8; Level of injury: paraplegia=24, quadriplegia=0; Level of	1. The intervention group reported greater scores in the Patient-Perceived Participation in Daily Activities than the control group.

$N_{(start)}$=24 $N_{(end)}$=22	severity: Not reported; Time since injury=15.45±12.85yr. **Intervention:** Participants were randomized to either an intervention group which received one, 1-hour counselling session per week for 8 weeks via online video chat, or a control group who continued their regular routine. **Outcome Measures:** Patient-Perceived Participation in Daily Activities	
Kemp et al. 2011 USA RCT PEDro=1 N=58	**Population:** individuals with SCI paraplegia who were also experiencing shoulder pain; Mean age: 45yr; Gender: not reported; Level of injury: Mean time post-injury: 20.1yr. **Intervention:** Participants were randomized to either an exercise treatment or a control group. Participants in the treatment group participated in a 12wk, at-home, exercise and movement optimization program designed to strengthen shoulder muscles and modify movements related to upper extremity weight bearing. **Outcome Measures:** Wheelchair User's Shoulder Pain Index (WUSPI), Social Interaction Inventory (SII)	1. In the experimental group, significant improvements in SII scores ($p=0.03$). 2. No significant changes on SII were observed for the control group from baseline to post-intervention ($p>0.05$). 3. A significant interaction between WUSPI and SII scores was found in the experimental group from baseline to post-intervention ($p<0.001$), suggesting that decreases in shoulder pain was associated with increases in social participation.
Madhusmita et al. 2019 India RCT PEDro=8 N=124	**Population:** SCI; Integrated Yoga and Physiotherapy (IYP) Group: Mean age: 33.97yr; Gender: males=54, females=8; Level of injury: incomplete, (AIS)-C and (AIS)-D; Time since injury: >6mo Control Group: Mean age: 32.84yr; Gender: males=53,	1. The IYP group showed a significant improvement in SCIM compared to the control group ($p<0.001$).

	females=9; incomplete, (AIS)-C and (AIS)-D; Time post-injury: >6mo **Intervention:** Participants in the IYP group received 75 min (6 days/wk) of an integrated yoga intervention for 1 mo. The control group received physiotherapy only. Physiotherapy session for both groups lasted for 60min/day and 6 days/wk for 1mo **Outcome Measures**: Spinal Cord Injury Independence Measure (SCIM).	
Mulroy et al. 2011 USA RCT PEDro=5 N_{Inital}=80, N_{Final}=52	**Population:** SCI; *Intervention Group*: Mean age: 47yr; Gender: males= 31; females=9; Level of injury: Paraplegia=40; Injury severity: AIS A=25, AIS B=9, AIS C=3, AIS D=1, Unknown=2; Mean time post-injury: 17.9yr. *Control Group*: Mean age: 47yr; Gender: males=26, females=14; Level of injury: Paraplegia=40; Injury severity: AIS A=25, AIS B=5, AIS C=5, AIS D=1, Uknown=4; Mean time post injury: 22.3yr. **Intervention:** Participants were randomly allocated to either the exercise/movement optimization group or the attention control group. The exercise/movement optimization intervention consisted of a 12-wk home-based program of shoulder strengthening and stretching exercises, along with recommendations on how to optimize the movement technique of	1. Community activity, as measured with the SII, showed a significant greater increase for the exercise/movement optimization group than for the attention control group ($p<0.03$). 2. Improvements in community activity levels over were maintained at the 4-week follow-up assessment.

	transfers, raises, and wheelchair propulsion. The attention control group viewed a 1-h educational video. Outcome measures were assessed at baseline, at the end of the 12-week intervention, and at 4 weeks after the end of the intervention. **Outcome Measures:** Social Interaction Inventory (SII)	
Nooijen et al. 2017 The Netherlands RCT PEDro=6 $N_{Initial}$=45; N_{Final}=39	**Population**: *Intervention group*: Mean age: 44yr; Gender: males=17, females=3; Level of injury: Tetraplegia=7, Paraplegia (13); Mean time post-injury: 139 d. *Control group*: Mean age: 44yr; Gender: males=16, females=3; Level of injury: Tetraplegia=6, Paraplegia=13; Mean time post injury: 161 days. **Intervention**: *Intervention group*: A behavioral intervention promoting physical activity, involving 13 individual sessions delivered by a coach trained in motivational interviewing, beginning 2mo before and ending 6mo after discharge from inpatient rehabilitation. *Control group:* Regular rehabilitation. **Outcome Measures**: social participation (IMPACT-S)	1. Participation improved significantly 12 months after discharge (p<0.01).
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-	1. Participants showed a significant improvement in functional goal achievement compared to baseline (p<0.001).

	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:** Patient-Specific Functional Scale (SFS)	
Fundaro et al. 2018 Italy Pre-Post N=39	**Population:** SCI: n=21; Parkinson's Disease (PD): n=10; Stroke Event: n=8; Age range: 33 to 79yr; Gender: males=27, females=12; Level of injury (SCI): paraplegia (n=4), paraparesis (n=11), quadriplegia (n=1) quadriparesis (n=5). **Intervention:** Participants underwent robot gait training with Lokomat. The training period lasted for 4wk, with 30min session carried out 3x/wk. **Outcome Measures:** Functional Independence Measure (FIM).	1. All patients showed significant improvements in FIM scale.
McVeigh et al. 2009 Canada Observational N=90	**Population:** Age range: 16+yr; Gender: males=71, females=19; Level of injury: C5-L5; Level of severity: AIS A=37, AIS B-D=43; Mean time since injury: ≥1yr. **No Intervention:** Prospective	1. Both CIQ and RNL total mean scores were higher among sport participants versus non-sport participants ($p<0.05$). 2. The home and social subscales of the CIQ showed the largest difference in mean subscale

	study to determine whether community integration and/or quality of life (QOL) among people with chronic spinal cord injury (SCI) are superior among sport participants versus non-sport participants. **Outcome Measures:** Community Integration Questionnaire (CIQ), Reintegration to Normal Living Index (RNL).	scores between the sport (t(88)=3.27, p=0.02) and non-sport (t(88)=4.42, p=0.00) groups, with the sport group demonstrating the higher scores.
Sweet et al. 2013 Canada Prospective N=395	**Population:** Age=45.68±14.05yr; Gender: males=298, females=95; Level of injury: paraplegia=190, tetraplegia=194; Level of severity: ASIA A=254, ASIA B/C/D=134; Time since injury=13.51±10.35yr. **No Intervention:** Using a prospective design, this study examined potential intermediary constructs linking LTPA and QOL in people with SCI. Drawing from previous literature, a longitudinal structural equation model was developed and tested to determine if depression, functional independence, social integration/participation, and self-efficacy mediate the LTPA–QOL relationship. **Outcome Measures:** Functional Independence Measure (FIM), Social integration subscale of the Craig Handicap Assessment and Reporting Technique Short-Form (CHART-SF).	1. LTPA at baseline significantly and positively predicted 6-month FIM scores. 2. Functional independence (FIM) scores were statistically significant mediators of the LTPA-QOL relationship. 3. Social integration/participation (CHART-SF) did not mediate the LTPA-QOL relationship.

Discussion

Description of studies. Compared to the other sub-sections within this chapter, fewer studies have examined the relationship between LTPA and participation-related outcomes. From these 9 studies, five were randomized controlled trials, one prospective controlled trial, two observational, and one pre-post study. The included studies were from different countries, including Canada (n = 3), USA (n=2), Netherlands (n=1), Australia (n=1), Italy (n=1), and India (n=1). The majority of studies have been conducted in high-income countries, limiting our knowledge of this relationship in low- or middle-income countries.

The LTPA and participation-related outcomes relationship. Across all studies, LTPA had a positive relationship with participation in daily and social activities, meaning that greater LTPA is related to greater participation. These promising results remain limited by the small number of studies, thus requiring further research. Another important limitation of this research is that most studies examine participation as a single, overall concept. Participation includes a number of independent activities that range from self-care to social activities. Currently, we have little knowledge on the relationship between LTPA and specific types of participation activities. For instance, McVeigh et al. (2009) demonstrated differences on home and social subscales among individuals who participated in sports or not. In another sample of individuals with physical disabilities, Sweet et al. (2021) found that individuals participating in a community-based LTPA program increased participation in family-based activities (e.g., preparing dinner) but not autonomous outdoor activities (e.g., moving outside the home). Future research could examine the relationship between types of LTPA and specific participation activities (or at least specific grouping of activities; e.g., self-care, social) to help optimize the design of LTPA interventions aimed to promote participation.

Moreover, the interventions reported varied from home-based, to person-centered, to supervised LTPA programs. This variability combined with the limited number of studies makes it impossible to conclude how to best intervene to improve participation. Further, these studies were primarily LTPA promotion studies where participation was not the primary outcome, but one of many secondary/tertiary outcomes. Effects could be stronger if the physical activities that are chosen are directly targeted or explicitly aimed to enhance specific participation activities. For example, Mulroy et al. (2011) and Kemp et al. (2011) provided a home-based program to optimize shoulder strength for shoulder-based activities (e.g., transfers, propulsion). Despite not finding effects on wheelchair propulsion speed and LTPA, Kemp et al. (2011) reported significant differences for participation in community activities and preparatory activities and, to a lesser extent, social activities. Interestingly, Kemp et al. (2011) noted that changes were mostly associated with community activities and preparatory subscale. These studies provide an initial example for future LTPA interventions aimed to specifically increase participation in daily and social activities.

Although it was beyond the scope of this section to compare and contrast measures and results of person-perceived or society-perceived participation, it may be an important next step in understanding the role of LTPA on participation. For example, do LTPA interventions (or types of interventions) differently impact person- vs society-perceived participation? Such an exploration could help identify which participation-related outcome measure may be most sensitive to (types of) LTPA.

In conclusion, there is a promising and positive association between LTPA and participation in daily and social activities. Excellent opportunities to investigate new avenues and conduct additional research to strengthen the current conclusions remain.

Conclusion

There is level 1a evidence from three RCTs - as well as support from two lower quality RCTs, one prospective control trial, one pre-post study - that physical activity-based interventions are effective for increasing participation in daily and social activities among persons with SCI.

5.0 Gaps in the Evidence

Across all three subsections, the majority of research is being conducted in high income countries. To truly understand the LTPA relationship with psychosocial outcomes, we need better diversity in study samples and countries of origin. It is difficult (and nearly impossible) to generalize these results on a worldwide scale without evidence representing our global society. Notably, research in other countries should be primarily led by researchers from those countries. If research is to be done in partnership, researchers must avoid being “helicopter” researchers and engaging in tokenistic research. They must be sensitive to the long tradition of such practices and ensure meaningful engagement (Adame, 2021; Anderson, 2021). Meaningful engaging in research can be conducted by following principles, such as the integrated knowledge translation principles for SCI research (Gainforth et al., 2021).

Although there is a growing body of literature examining the relationship between LTPA and anxiety and depression, there remains some important gaps. Most studies examined symptoms of anxiety and/or depression rather than identifying the impact of LTPA on people with SCI who have a clinical anxiety/depression diagnosis. It is therefore difficult to ascertain the potential clinical implications of participating in LTPA without conducting research on people who have a clinical diagnosis. Similarly, the ideal dosage of LTPA on these psychological outcomes remains largely unknown. Conducting high quality

interventions to determine the impact of LTPA on anxiety and depression and identifying the ideal dose of LTPA is needed to fill an important gap in the SCI research. These interventions should ensure that anxiety and depression are their primary outcome and include follow-up assessments to ascertain the potential longer-term impact of LTPA. Furthermore, most of these studies examined depression and anxiety among men. More research is needed to examine sex/gender differences and possible considerations sex/gender has on the LTPA and depression/anxiety relationship.

A large body of research has shown support for the LTPA and QOL relationship. Notably, research on LTPA and subjective QOL has grown in the past two decades. This continued growth is encouraging because the LTPA and subjective QOL relationship needs further unpacking in light of some studies reporting non-significant results. Future research could differentiate the relationship between LTPA and the physical, psychological, and social domains of QOL. Such information may help optimize the selection of the types of LTPA and measures of QOL when developing and evaluating LTPA interventions and programs.

A limited body of research has explored the relationship between LTPA and participation-related outcomes, requiring more research to strengthen conclusions. Future research could aim to explore the relationship between LTPA and the various types and domains of participation. Given participation is a broad concept and most studies in this review focused on participation as one broad outcome, we have little knowledge of specific relationships between different types of LTPA and different participation-related outcomes. Gaining evidence for these specific associations could inform interventions and community-based programs. Furthermore, participation may need to be a primary outcome in LTPA interventions. Bringing the focus on participation as a key outcome may assist in selecting types of physical activities used in an intervention and enhance our understanding of this relationship. Finally, studies could aim to examine whether LTPA has a stronger or weaker relationship with person-perceived or society-perceived participation. Such an understanding is required to ensure researchers select the participation-related outcomes that are most sensitive to change from participating in LTPA.

Finally, across all sections in this review, the majority of interventions and trials have been conducted with small samples and mostly with men. These small samples reduce the likelihood of identifying significant results even if moderate effect sizes were found. Interventions and trials with larger sample sizes are needed. Larger samples in LTPA interventions would also help to fill some important gaps in the literature, including examining sex/gender differences in these relationships. For example, what is the ideal dose of LTPA to increase QOL or reduce depression? What type of physical activity (e.g., yoga, tai chi, resistance training) is ideal to enhance QOL or reduce anxiety? What are mechanisms that may explain the relationship between LTPA and these psychological and

participation-related outcomes and are they different for men and women? As such, there remains a number of different avenues to explore before coming to a comprehensive understanding of the effect and relationship of LTPA with depression, anxiety, quality of life, and participation-related outcomes.

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7.0 Abbreviations

LTPA Leisure time physical activity
QOL Quality of life
SCI Spinal cord injury