Evidence Portfolio – Chronic Conditions Subcommittee, Question 6

In individuals with a spinal cord injury, what is the relationship between physical activity and (1) risk of co-morbid conditions, (2) physical function, and (3) health-related quality of life?

Sources of Evidence: Systematic Reviews and Meta-Analyses

Conclusion Statements and Grades

RISK OF CO-MORBID CONDITIONS
Limited evidence suggests that physical activity reduces shoulder pain and improves vascular function in paralyzed limbs in individuals with spinal cord injury. **PAGAC Grade: Limited.**

PHYSICAL FUNCTION
Moderate evidence indicates that physical activity improves walking function, muscular strength, and upper extremity function for persons with spinal cord injury. **PAGAC Grade: Moderate**.

HEALTH-RELATED QUALITY OF LIFE
Limited evidence suggests physical activity improves health-related quality of life in individuals with spinal cord injury. **PAGAC Grade: Limited.**

Description of the Evidence

The Chronic Conditions Subcommittee chose to rely exclusively on existing reviews including systematic reviews, meta-analyses, pooled analyses, and reports for this question. As determined by the Subcommittee, the search for existing reviews identified sufficient literature to answer the research question. Additional searches for original research were not conducted based on the a priori decision to focus on existing reviews.

RISK OF CO-MORBID CONDITIONS

Existing Systematic Reviews

Overview

A total of 3 systematic reviews were included.[1-3] The reviews were published between 2011 and 2015 and included a range of 7 to 82 studies. Two systematic reviews covered extensive timeframes: from inception to 2010[2] and from 1966 to 2014.[1] One systematic review included studies published since 1950 but did not report the upper limit for the publication year.[3]

Exposures

The included reviews examined physical activity interventions that incorporated stretching and strengthening home exercise programs,[1] resistance exercises,[2] combined aerobic and resistance training,[2] functional electrical stimulation,[2, 3] and passive cycling and body-weight supported treadmill training.[3]

Outcomes

One systematic review addressed shoulder pain measured by the *Wheelchair Users Shoulder Pain Index (WUSPI)* as an outcome.[1] Hicks et al[2] reported changes in body composition, including lean and fat mass. Phillips et al[3] addressed change in vascular function, including vascular resistance and leg blood flow.

PHYSICAL FUNCTION

Existing Systematic Reviews and Meta-Analyses

Overview

A total of 8 existing reviews were included: 6 systematic reviews[2, 4-8] and 2 meta-analyses.[9, 10] The reviews were published between 2011 and 2017.

The systematic reviews[2, 4-8] included a range of 8 to 82 studies. The reviews covered extensive timeframes: from inception to 2010,[2] inception to 2012,[8] inception to 2013,[4] inception to 2015,[6] inception to 2016,[5] and from 1950 to 2013.[7] The two meta-analyses included 13 and 19 studies and covered an extensive search timeframe: from inception to 2016.[9, 10]

Exposures

The majority of the systematic reviews examined physical activity interventions that incorporated aerobic and muscle strengthening exercise.[2, 4, 5, 7] Some studies also examined aquatic exercise programs like swimming and underwater walking[6] and treadmill training.[8]

The included meta-analyses examined physical activity interventions that incorporated robotic-assisted gait training, body weight supported treadmill training,[9] balance training, kayaking, tai chi, and rockerboard exercises.[10]

Outcomes

All reviews addressed physical function as an outcome. Most systematic reviews examined walking[2, 5, 6, 8] or cardiovascular fitness and muscular strength[2, 4, 6] as an outcome. The meta-analyses addressed physical function as an outcome via assessing walking performance, speed, capacity, and distance,[9] and functional sitting and standing balance and postural control.[10]

HEALTH-RELATED QUALITY OF LIFE

Existing Systematic Reviews

Overview

A total of 2 systematic reviews were included.[4, 11] The reviews were published in 2013 and 2015 and included a range of 9 to 11 studies. The 2 systematic reviews covered extensive timeframes: from inception to 2012,[11] and inception to 2013.[4]

Exposures

The included reviews[4, 11] examined the effects of aerobic training and muscle strengthening on the outcome.

Outcomes

The reviews addressed quality of life as an outcome, assessed via the Perceived Quality of Life scale, Life Satisfaction Scale, or Quality of Life Profile.[4, 11]

Populations Analyzed

The table below lists the populations analyzed in each article.

Table 1. Populations Analyzed by All Sources of Evidence

	Age	Chronic Conditions
Bochkezanian, 2015	Adults ≥18	Spinal cord injury
Cratsenberg, 2015	Adults ≥18	Spinal cord injury
Gandhi, 2017	Children and adults 1–17	Spinal cord injury
Hicks, 2011	Adults	Spinal cord injury (acute vs. chronic)
Kawanishi, 2013	Adults	Spinal cord injury
Li, 2017	Adults 18–63	Spinal cord injury
Lu, 2015		Spinal cord injury
Mehrholz, 2017	Children and adults 16–68	Spinal cord injury
Phillips, 2011		Spinal cord injury
Tse, 2017	Children and adults >16	Spinal cord injury
Yang, 2012	Adults	Spinal cord injury

Supporting Evidence

Existing Systematic Reviews and Meta-Analyses

Table 2. Existing Systematic Reviews and Meta-Analyses Individual Evidence Summary Tables

<table>
<tr><th colspan="2">Health-Related Quality of Life, Physical Function</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Bochkezanian V, Raymond J, de Oliveira CQ, Davis GM. Can combined aerobic and muscle strength training improve aerobic fitness, muscle strength, function and quality of life in people with spinal cord injury? A systematic review. Spinal Cord. 2015;53(6):418-431. doi:10.1038/sc.2015.48.</td></tr>
<tr><td>Purpose: To investigate whether combined aerobic training and muscle strength conditioning is effective for improving aerobic fitness, muscle strength functional outcomes, and/or quality of life in people with spinal cord injury.</td><td rowspan="5">Abstract: STUDY DESIGN: A systematic review. OBJECTIVES: The aim of this systematic review was to establish whether combined aerobic training and muscle strength training is effective in improving aerobic fitness, muscle strength, function and/or quality of life (QoL) in people with spinal cord injury (SCI). SETTINGS: Faculty of Health Sciences. University of Sydney, NSW, Australia. METHODS: A search was conducted for randomized controlled trials (RCTs), controlled trials, uncontrolled clinical trials, case series and cross-over studies involving exercise interventions that included a combination of aerobic and strength components, either in circuit-mode or in sequence for people with SCI. Methodological quality was independently rated using the PEDro scale and key findings were extracted from trials by two reviewers. RESULTS: The search identified 7981 abstracts, from which nine trials met the inclusion criteria. From the nine selected trials, seven reported aerobic outcomes, two of which showed a statistically significant within-group difference in aerobic fitness. Five studies reported muscle strength outcomes, four of them showed a statistically significant within-group mean difference on at least one outcome measure. Two studies looked at QoL, one of them found a statistically significant between-group difference on one outcome measure. CONCLUSION: Our systematic review showed that literature on SCI population is scarce, of low quality and findings of existing studies are inconsistent. Thus, further RCTs with larger number of participants are needed to make a definite conclusion about the influence of combined aerobic and muscle strength training on aerobic fitness, muscle strength and QoL in people with SCI.</td></tr>
<tr><td>Timeframe: Inception–February 2013</td></tr>
<tr><td>Total # of Studies: 9</td></tr>
<tr><td>Exposure Definition: Exercise programs included were aerobic training and muscle strengthening. Programs lasted from 7 weeks to 9 months, with sessions usually occurring 2–3 times per week, and for 30–60 minutes.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Physical function: aerobic fitness (peak oxygen uptake), muscle strength (1 repetition maximum). Quality of life: questionnaires such as the Perceived Quality of Life scale (PQoL).
Examine Cardiorespiratory Fitness as Outcome: Yes</td></tr>
<tr><td>Populations Analyzed: Age ≥18, Spinal Cord Injury</td><td>Author-Stated Funding Source: Not reported.</td></tr>
</table>

<table>
<tr><th colspan="2">Risk of Co-Morbid Conditions</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Cratsenberg KA, Deitrick CE, Harrington TK, et al. Effectiveness of exercise programs for management of shoulder pain in manual wheelchair users with spinal cord injury. J Neurol Phys Ther. 2015;39(4):197-203. doi:10.1097/NPT.0000000000000103.</td></tr>
<tr><td>Purpose: To evaluate the effectiveness of exercise programs on the reduction of shoulder pain in manual wheel chair users with spinal cord injury.</td><td rowspan="5">Abstract: BACKGROUND AND PURPOSE: Shoulder pain is prevalent in manual wheelchair users (MWUs) with spinal cord injury (SCI). Therapeutic exercise has been demonstrated to be an effective, conservative approach to treating shoulder pain in able-bodied individuals. We sought to evaluate literature on the effectiveness of exercise programs on the reduction of shoulder pain in MWUs with SCI. METHODS: We searched the literature, using search terms related to SCI, manual wheelchairs, and shoulder pain. Eligibility criteria included prospective study design, exercise intervention for MWUs with shoulder pain, and use of the Wheelchair User's Shoulder Pain Index as an outcome measure. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and assessed study quality. RESULTS: Three randomized control trials and 4 cohort studies met inclusion criteria. Two studies were rated as good quality and 5 as fair quality. Three interventions were evaluated in the included studies: arm ergometry, resistive strengthening with or without electromyographic biofeedback, and stretching that targeted the muscles of the shoulder girdle. Across the 7 studies, the exercise intervention was associated with reduction in shoulder pain that exceeded the estimated minimal detectable change of 5.10 points for the Wheelchair Users' Shoulder Pain Index. DISCUSSION AND CONCLUSION: Exercise is a feasible, conservative, therapeutic intervention for the treatment of shoulder pain among MWUs. Additional studies are needed to differentiate techniques for the reduction of shoulder pain, to determine the most effective duration of intervention, and to estimate the magnitude of effect associated with therapeutic exercise for shoulder pain among MWUs.Video Abstract available for more insights from the authors (see Supplemental Digital Content 1, http://links.lww.com/JNPT/A116).</td></tr>
<tr><td>Timeframe: 1966–January 2014</td></tr>
<tr><td>Total # of Studies: 7</td></tr>
<tr><td>Exposure Definition: Exercise programs included stretching, home strengthening exercises, double pole ergometry, and arm ergometry. Programs varied in frequency, duration (8 weeks to 6 months), and length.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Quality of Life: Wheelchair User's Shoulder Pain Index (WUSPI).
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Age ≥18, Spinal Cord Injury</td><td>Author-Stated Funding Source: Not reported.</td></tr>
</table>

<table>
<tr><th colspan="2">Physical Function</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Gandhi P, Chan K, Verrier MC, Pakosh M, Musselman KE. Training to improve walking after pediatric spinal cord injury: a systematic review of parameters and walking outcomes. J Neurotrauma. 2017;34(9):1713-1725. doi:10.1089/neu.2016.4501.</td></tr>
<tr><td>Purpose: To address the who, what, when, and how of training to improve walking in children with spinal cord injury.</td><td rowspan="5">Abstract: Walking or locomotor training is often initiated following pediatric spinal cord injury (SCI). There is no synthesis of the literature on interventions targeting walking for pediatric SCI, although this would assist future clinical trials and interventions. To address this need, we completed a systematic review to summarize the who, what, when, and how of walking interventions in children with SCI. Participant characteristics, training parameters, and walking outcomes with training in pediatric SCI were identified and compared with training parameters and outcomes in adults with SCI. The PubMed, Medline, AMED, Embase, PsycInfo, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, and CINAHL databases were searched for studies that included participants aged 1-17 years with a SCI acquired post-birth, physical interventions, and pre- and post-training walking measures. Two researchers evaluated each study's risk of bias using a domain-based approach. Training parameters and walking outcomes were extracted. Total training duration (duration x frequency x number of weeks) was calculated. Thirteen pediatric studies (n = 43 children) were included; all but one were case series/reports. Risk of bias was high in the pediatric studies. A 2012 adult review was updated (11 studies added). As with adults, the training durations, frequencies, and modes used with the children varied; however, overground walking practice was included in 10/13 pediatric studies. Improvements in walking capacity, speed, and distance were comparable between children and adults. There was a trend for greater gains with greater total training durations. There is a paucity of high-quality research examining interventions targeting walking after pediatric SCI; however, intensive training, including practice overground, results in notable improvements.</td></tr>
<tr><td>Timeframe: Inception–May 2016</td></tr>
<tr><td>Total # of Studies: 13</td></tr>
<tr><td>Exposure Definition: Exercise programs included walking practice, strengthening exercises, conventional therapy, and body weight stabilizing treadmill training. Sessions ranged for at least 2–6 sessions/week, for 20–240 minutes, and lasted for 6–24 weeks.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Physical function: walking ability (10 minute walk test, 6 minute walk test, and Walking index for spinal cord injury II (WISCI II)).
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Age 1–17, Spinal Cord Injury</td><td>Author-Stated Funding Source: Ontario Neurotrauma Foundation.</td></tr>
</table>

<table>
<tr><th colspan="2">Risk of Co-Morbid Conditions, Physical Function</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Hicks AL, Martin Ginis KA, Pelletier CA, Ditor DS, Foulon B, Wolfe DL. The effects of exercise training on physical capacity, strength, body composition and functional performance among adults with spinal cord injury: a systematic review. Spinal Cord. 2011;49(11):1103-1127. doi:10.1038/sc.2011.62.</td></tr>
<tr><td>Purpose: To conduct a systematic review of evidence surrounding the effects of exercise on physical fitness in people with spinal cord injury.</td><td rowspan="5">Abstract: STUDY DESIGN: Systematic review. OBJECTIVES: To conduct a systematic review of evidence surrounding the effects of exercise on physical fitness in people with spinal cord injury (SCI). SETTING: Canada. METHODS: The review was limited to English-language studies (published prior to March 2010) of people with SCI that evaluated the effects of an exercise intervention on at least one of the four main components of physical fitness (physical capacity, muscular strength, body composition and functional performance). Studies reported at least one of the following outcomes: oxygen uptake/consumption, power output, peak work capacity, muscle strength, body composition, exercise performance or functional performance. A total of 166 studies were identified. After screening, 82 studies (69 chronic SCI; 13 acute SCI) were included in the review. The quality of evidence derived from each study was evaluated using established procedures. RESULTS: Most studies were of low quality; however, the evidence was consistent that exercise is effective in improving aspects of fitness. There is strong evidence that exercise, performed 2-3 times per week at moderate-to-vigorous intensity, increases physical capacity and muscular strength in the chronic SCI population; the evidence is not strong with respect to the effects of exercise on body composition or functional performance. There were insufficient high-quality studies in the acute SCI population to draw any conclusions. CONCLUSIONS: In the chronic SCI population, there is good evidence that exercise is effective in improving both physical capacity and muscular strength, but insufficient quality evidence to draw meaningful conclusions on its effect on body composition or functional capacity.</td></tr>
<tr><td>Timeframe: Inception–March 2010</td></tr>
<tr><td>Total # of Studies: 82</td></tr>
<tr><td>Exposure Definition: Variety of exercise interventions, including aerobic training, resistance training, muscle stimulation, wheelchair interval training, and arm ergometry training. Intensity, time, frequency, and duration varied.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Walking (e.g., speed, percentage body-weight support required). Functional performance (e.g., wheelchair skills and propulsion, walking and standing). Power output. Muscle strength.
Examine Cardiorespiratory Fitness as Outcome: Yes</td></tr>
<tr><td>Populations Analyzed: Adults, Spinal Cord Injury (acute vs. chronic)</td><td>Author-Stated Funding Source: Rick Hansen Institute, Research Council of Canada, Canadian Institutes of Health, and Ontario Neurotrauma Foundation.</td></tr>
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<tr><th colspan="2">Health-Related Quality of Life</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Kawanishi CY, Greguol M. Physical activity, quality of life, and functional autonomy of adults with spinal cord injuries. Adapt Phys Activ Q. 2013;30(4):317-337.</td></tr>
<tr><td>Purpose: To analyze the findings on the association between PA, functional independence, and quality of life in adults with spinal cord injury.</td><td rowspan="5">Abstract: This study aimed to perform a systematic review of studies that address the influence of physical activity on the quality of life and functional independence of adult individuals with spinal cord injury. The review was performed using data obtained from the MEDLINE, CINAHL, SciELO, LILACS, SPORTDiscus, Web of Science, Academic Search Premier, and PEDro databases using the following keywords: quality of life; functional independence; autonomy; independence; physical activity; activities of daily living; physical exercise; tetraplegia; paraplegia; spinal cord injury; physical disabilities; and wheelchair. Eleven studies met the inclusion criteria. Although there was a lack of consensus among the selected studies, the majority of them presented a strong correlation between physical activity and variables of quality of life and/or functional independence. Thus, physical activity appears to have an important influence on social relationships, functional independence, psychological factors, and physical aspects, which can enhance quality of life and independence in the performance of daily activities.</td></tr>
<tr><td>Timeframe: Inception–September 2012</td></tr>
<tr><td>Total # of Studies: 11</td></tr>
<tr><td>Exposure Definition: Exercise programs included weight training, swimming, and treadmill walking. Some programs assessed existing engagement in leisure time physical activity. Programs varied in frequency, duration, and length.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Quality of life: questionnaires including Quality of Life scale, Life Satisfaction Scale, and Quality of Life Profile. Physical and Sensory Disabilities Version. Physical Function: functional independence, aerobic training, and muscle strengthening.
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Adults, Spinal Cord Injury</td><td>Author-Stated Funding Source: Not reported.</td></tr>
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Physical Function	
Systematic Review **Citation:** Li C, Khoo S, Adnan A. Effects of aquatic exercise on physical function and fitness among people with spinal cord injury: a systematic review. *Medicine (Baltimore)*. 2017;96(11):e6328. doi:10.1097/MD.0000000000006328.	
Purpose: To summarize the evidence for the effects of aquatic exercise on physical function and fitness among people with spinal cord injury. **Timeframe:** Inception–June 2015 **Total # of Studies:** 8 **Exposure Definition:** Aquatic exercise programs included swimming and underwater walking. Most programs lasted for 8–16 weeks, with sessions varying 2–6 times per week and lasting 20–60 minutes. **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No **Outcomes Addressed:** Physical function: functional independence, muscle contraction, mobility, walking ability, and physical fitness (e.g., aerobic or cardiovascular fitness (force vital capacity), balance, muscular endurance, and strength)). **Examine Cardiorespiratory Fitness as Outcome:** Yes	**Abstract:** OBJECTIVE: The aim of this review is to synthesize the evidence on the effects of aquatic exercise interventions on physical function and fitness among people with spinal cord injury. DATA SOURCE: Six major databases were searched from inception till June 2015: MEDLINE, CINAHL, EMBASE, PsychInfo, SPORTDiscus, and Cochrane Center Register of Controlled Trials. STUDY APPRAISAL AND SYNTHESIS METHODS: Two reviewers independently rated methodological quality using the modified Downs and Black Scale and extracted and synthesized key findings (i.e., participant characteristics, study design, physical function and fitness outcomes, and adverse events). RESULTS: Eight of 276 studies met the inclusion criteria, of which none showed high research quality. Four studies assessed physical function outcomes and 4 studies evaluated aerobic fitness as outcome measures. Significant improvements on these 2 outcomes were generally found. Other physical or fitness outcomes including body composition, muscular strength, and balance were rarely reported. CONCLUSIONS AND IMPLICATIONS OF KEY FINDINGS: There is weak evidence supporting aquatic exercise training to improve physical function and aerobic fitness among adults with spinal cord injury. Suggestions for future research include reporting details of exercise interventions, evaluating other physical or fitness outcomes, and improving methodological quality.
Populations Analyzed: Age 18–63, Spinal Cord Injury	**Author-Stated Funding Source:** University of Malaya.

<table>
<tr><th colspan="2">Physical Function</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Lu X, Battistuzzo CR, Zoghi M, Galea MP. Effects of training on upper limb function after cervical spinal cord injury: a systematic review. Clin Rehabil. 2015;29(1):3-13. doi:10.1177/0269215514536411.</td></tr>
<tr><td>Purpose: To evaluate the effectiveness of training aimed at promoting recovery of upper limb/hand function from clinical trials involving people with cervical spinal cord injury.</td><td rowspan="5">Abstract: OBJECTIVE: To summarize the evidence for the effectiveness of exercise training in promoting recovery of upper extremity function after cervical spinal cord injury. DATA SOURCES: Medline, Cochrane, CINAHL, EMBASE and PEDro were used to search the literature. REVIEW METHODS: Two reviewers independently selected and summarized the included studies. Methodological quality of the selected articles was scored using the Downs and Black checklist. RESULTS: A total of 16 studies were included, representing a total of 426 participants. Overall, the internal validity and reporting of the studies was fair to good, while power and external validity were poor. Interventions included exercise therapy, electrical stimulation, functional electrical stimulation, robotic training and repetitive transcranial magnetic stimulation. Most of the studies reported improvements in muscle strength, arm and hand function, activity of daily living or quality of life after intervention. CONCLUSIONS: Training including exercise therapy, electrical stimulation, functional electrical stimulation of the upper limb following cervical spinal cord injury leads to improvements in muscle strength, upper limb function and activity of daily living or quality of life. Further research is needed into the effects of repetitive transcranial magnetic stimulation and robotic training on upper limb function.</td></tr>
<tr><td>Timeframe: 1950–November 2013</td></tr>
<tr><td>Total # of Studies: 16</td></tr>
<tr><td>Exposure Definition: Exercise programs included robotic training, aerobic ergometry, repetitive transcranial magnetic stimulation, functional electrical stimulation, resistance training, and biofeedback. Programs lasted from 2 weeks to 9 months (most 6–8 weeks), with varying frequency and duration of sessions.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Physical Function: strength, hand, or arm function, and activities of daily living (quadriplegia index of function, Functional Independence Measure, and other questionnaires). Quality of Life.
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Cervical Spinal Cord Injury</td><td>Author-Stated Funding Source: No funding source used.</td></tr>
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<table>
<tr><th colspan="2">Physical Function</th></tr>
<tr><td colspan="2">Meta-Analysis
Citation: Mehrholz J, Harvey LA, Thomas S, Elsner B. Is body-weight-supported treadmill training or robotic-assisted gait training superior to overground gait training and other forms of physiotherapy in people with spinal cord injury? A systematic review. Spinal Cord. 2017;55(8):722-729. doi:10.1038/sc.2017.31.</td></tr>
<tr><td>Purpose: To compare the effectiveness of body weight supported treadmill training and robotic-assisted gait training with overground gait training and other forms of physiotherapy on walking speed and walking distance in people with traumatic spinal cord injury.</td><td rowspan="5">Abstract: STUDY DESIGN: Systematic review about randomised trials comparing different training strategies to improve gait in people with spinal cord injuries (SCI). OBJECTIVES: The aim of this systematic review was to compare the effectiveness of body-weight-supported treadmill training (BWSTT) and robotic-assisted gait training with overground gait training and other forms of physiotherapy in people with traumatic SCI. SETTING: Systematic review conducted by researchers from Germany and Australia. METHODS: An extensive search was conducted for randomised controlled trials involving people with traumatic SCI that compared either BWSTT or robotic-assisted gait training with overground gait training and other forms of physiotherapy. The two outcomes of interest were walking speed (m s-1) and walking distance (m). BWSTT and robotic-assisted gait training were analysed separately, and data were pooled across trials to derive mean between-group differences using a random-effects model. RESULTS: Thirteen randomised controlled trials involving 586 people were identified. Ten trials involving 462 participants compared BWSTT to overground gait training and other forms of physiotherapy, but only nine trials provided useable data. The pooled mean (95% confidence interval (CI)) between-group differences for walking speed and walking distance were -0.03 m s-1 (-0.10 to 0.04) and -7 m (-45 to 31), respectively, favouring overground gait training. Five trials involving 344 participants compared robotic-assisted gait training to overground gait training and other forms of physiotherapy but only three provided useable data. The pooled mean (95% CI) between-group differences for walking speed and walking distance were -0.04 m s-1 (95% CI -0.21 to 0.13) and -6 m (95% CI -86 to 74), respectively, favouring overground gait training. CONCLUSIONS: BWSTT and robotic-assisted gait training do not increase walking speed more than overground gait training and other forms of physiotherapy do, but their effects on walking distance are not clear.</td></tr>
<tr><td>Timeframe: Inception–September 2016</td></tr>
<tr><td>Total # of Studies: 13</td></tr>
<tr><td>Exposure Definition: Exercise included robotic-assisted gait training, body weight supported treadmill training, or a combination of both. Exercise was performed 2–5 times per week, for 4–16 weeks. Each session lasted between 25–60 minutes.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Physical Function: walking speed (10–15 minutes walk test) or walking distance (6 minute walk test).
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Age 16–68, Traumatic Spinal Cord Injury</td><td>Author-Stated Funding Source: Not reported.</td></tr>
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<tr><th colspan="2">Risk of Co-Morbid Conditions</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Phillips AA, Cote AT, Warburton DE. A systematic review of exercise as a therapeutic intervention to improve arterial function in persons living with spinal cord injury. Spinal Cord. 2011;49(6):702-714. doi:10.1038/sc.2010.193.</td></tr>
<tr><td>Purpose: To present a synopsis of the scientific literature investigating the usefulness of various exercise strategies to improve vascular function in denervated limbs of those with spinal cord injury.<hr>Timeframe: 1950–Not reported<hr>Total # of Studies: 28<hr>Exposure Definition: Acute exercise (passive leg exercise, functional electrical stimulation, single muscle electrical stimulation, upper body continuous aerobic exercise, combined arm passive leg exercise, and stretching induced contractions) and non-acute exercise (passive leg exercise, functional electrical stimulation, upper body exercise, electrically stimulated resistance training regimen, hybrid exercise, and body-weight support treadmill training).
Measures Steps: No
Measures Bouts: No
Examines HIIT: No<hr>Outcomes Addressed: Arterial structure and function (e.g., maximum blood velocity, femoral blood flow, vasodilation and vasoconstriction during and after exercise).
Examine Cardiorespiratory Fitness as Outcome: No</td>
<td>Abstract: STUDY DESIGN: All randomized controlled trials, prospective cohort, case-controlled, pre-post studies and case reports that assessed exercise interventions, which influence arterial structure and function after spinal cord injury (SCI), were included. OBJECTIVE: To review systematically the evidence for exercise as a therapy to alter arterial function in persons with SCI. SETTING: Literature searches were conducted for appropriate articles using several electronic databases (e.g. MEDLINE, EMBASE). METHODS: Three independent reviewers evaluated each investigation’s quality, using the Physiotherapy Evidence Database Scale for randomized controlled trials and Downs and Black Scale for all other studies. Results were tabulated and levels of evidence assigned. RESULTS: A total of 283 studies were found through the systematic literature search. Upon review of the articles, 27 were included. The articles were separated into those investigating arterial benefits, resulting from either acute bouts of exercise or long-term exercise interventions. The ability of both acute and long-term exercise interventions to improve arterial structure and function in those with SCI was supported by limited to moderate methodological quality. Upper body wheeling is the most commonly examined exercise therapy for improving arterial function. It appears from the evidence that a variety of exercise interventions, including passive exercise, upper body wheeling, functional electrical stimulation and electrically stimulated resistance exercise, can improve arterial function in those living with SCI. CONCLUSIONS: Although the quality and volume of evidence is low, the literature supports exercise as a useful intervention technique for improving arterial function in those with SCI.</td></tr>
<tr><td>Populations Analyzed: Spinal Cord Injury</td><td>Author-Stated Funding Source: Canadian Institutes of Health Research, the Michael Smith Foundation for Health Research, the Natural Sciences and Engineering Research Council of Canada, the Canada Foundation for Innovation, the BC Knowledge Development Fund.</td></tr>
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Physical Function	
Meta-Analysis **Citation:** Tse CM, Chisholm AE, Lam T, Eng JJ. A systematic review of the effectiveness of task-specific rehabilitation interventions for improving independent sitting and standing function in spinal cord injury. *J Spinal Cord Med.* July 2017:1-13. doi:10.1080/10790268.2017.1350340.	
Purpose: To investigate the effect of task-based rehabilitation training on postural stability and balance during sitting and standing in people with acute or chronic spinal cord injury. **Timeframe:** Inception–June 2016 **Total # of Studies:** 19 **Exposure Definition:** Rehabilitation interventions involving task-based balance training. Exercise included unsupported sitting, kayaking, Tai Chi, rockerboard exercises, and treadmill with balance exercises. Session duration ranged from 0.4–3 hours, frequency of 2–5 days per week, with a length of 4–13 weeks. **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No **Outcomes Addressed:** Functional sitting and standing balance: sit and reach test, Tinetti balance scores, Berg's balance scale, and other balance measures. **Examine Cardiorespiratory Fitness as Outcome:** No	**Abstract:** Context Impaired balance function after a spinal cord injury (SCI) hinders performance of daily activities. Objective To assess the evidence on the effectiveness of task-specific training on sitting and standing function in individuals with SCI across the continuum of care. Methods A systematic search was conducted on literature published to June 2016 using people (acute or chronic SCI), task-specific interventions compared to conventional physical therapy, and outcome (sitting or standing balance function). The PEDro scale was used to investigate the susceptibility to bias and trial quality of the randomized controlled trials (RCTs). A standardized mean difference (SMD) was conducted to investigate the effect size for interventions with sitting or standing balance outcomes. Results Nineteen articles were identified; three RCTs, two prospective controlled trials, one cross-over study, nine pre-post studies and four prospective cohort studies. RCT and cross-over studies were rated from 6 to 8 indicating good quality on the PEDro scale. The SMD of task-specific interventions in sitting compared to active and inactive (no training) control groups was -0.09 (95% CI: -0.663 to 0.488) and 0.39 (95% CI: -0.165 to 0.937) respectively, indicating that the addition of task-specific exercises did not affect sit and reach test performance significantly. Similarly, the addition of BWS training did not significantly affect BBS compared to conventional physical therapy -0.36 (95% CI: -0.840 to 0.113). Task-specific interventions reported in uncontrolled trials revealed positive effects on sitting and standing balance function. Conclusion Few RCT studies provided balance outcomes, and those that were evaluated indicate negligible effect sizes. Given the importance of balance control underpinning all aspects of daily activities, there is a need for further research to evaluate specific features of training interventions to improve both sitting and standing balance function in SCI.
Populations Analyzed: Age >16, Spinal Cord Injury	**Author-Stated Funding Source:** No funding source used.

Physical Function	
Systematic Review **Citation:** Yang JF, Musselman KE. Training to achieve over ground walking after spinal cord injury: a review of who, what, when, and how. *J Spinal Cord Med*. 2012;35(5):293-304. doi:10.1179/2045772312Y.0000000036.	
Purpose: To determine the client characteristics and training methods that brought about independent over ground walking (i.e., not requiring manual assistance, electrical stimulation, or extensive bracing such as reciprocating gait orthoses) after spinal cord injury.	**Abstract:** OBJECTIVES: (1) To provide clinicians with the best evidence for effective retraining of walking after spinal cord injury (SCI) to achieve over ground walking. (2) To identify gaps in our knowledge to guide future research. METHODS: Articles that addressed the retraining of walking in adults with SCI and reported outcome measures of over ground walking ability were identified through a non-systematic search of the PubMed, Scopus, and CINAHL databases. No restriction was applied to the method of training. Selected articles were appraised using the Physiotherapy Evidence Database scale. Information was synthesized to answer who best responds to what type of treatment, how that treatment should be delivered, and at what stage after injury. RESULTS: Individuals with motor incomplete SCI (American Spinal Injury Association (ASIA) Impairment scale (AIS) C and D) are most likely to regain walking over ground. The effective methods of training all involved a substantial component of walking in the training, and if assistance was provided, partial assistance was more effective than total assistance. Walking training resulted in a change in over ground walking speed of 0.06-0.77 m/s, and 6 minute walk distance of 24-357 m. The effective training schedules ranged from 10 to 130 sessions, with a density of sessions ranging from 2 per week to 5 per week. Earlier training led to superior results both in the subacute (<6 months) and chronic phases (>6 months) after injury, but even individuals with chronic injuries of long duration can improve. CONCLUSIONS: Frequent, early treatment for individuals with motor incomplete SCI using walking as the active ingredient whether on the treadmill or over ground, generally leads to improved walking over ground. Much work remains for the future, including better quantification of treatment intensity, better outcome measures to quantify a broader range of walking skills, and better ways to retrain individuals with more severe lesions (AIS A and B).
Timeframe: Inception–June 2012	
Total # of Studies: 20	
Exposure Definition: Supervised walking training on a treadmill or over ground, including robot-assisted feedback and manually assisted feedback ranging from 10 to 130 sessions with a density of sessions from 2 to 5 times/week. **Measures Steps:** No **Measures Bouts:** No **Examines HIIT:** No	
Outcomes Addressed: Improved walking speed, distance: 6-minute walk test. Scores: Wernig Walking Scale. **Examine Cardiorespiratory Fitness as Outcome:** No	
Populations Analyzed: Adults, Spinal Cord Injury	**Author-Stated Funding Source:** Christopher and Dana Reeve Foundation, the Alberta Paraplegic Foundation, the Rick Hansen Foundation, the Canadian Institutes of Health Research.

Table 3. Existing Systematic Reviews and Meta-Analyses Quality Assessment Chart

AMSTARExBP: SR/MA	Bochkezanian, 2015	Cratsenberg, 2015	Gandhi, 2017	Hicks, 2011	Kawanishi, 2013	Li, 2017	Lu, 2015
Review questions and inclusion/exclusion criteria delineated prior to executing search strategy.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population variables defined and considered in methods.	No	No	Yes	Yes	No	Yes	No
Comprehensive literature search performed.	Yes	Yes	Yes	Yes	Partially Yes	Yes	Yes
Duplicate study selection and data extraction performed.	Yes	Yes	Yes	Yes	No	Yes	Yes
Search strategy clearly described.	Yes	No	Yes	Yes	Yes	Yes	Yes
Relevant grey literature included in review.	No	No	Yes	Yes	No	Yes	No
List of studies (included and excluded) provided.	No	No	No	Yes	No	No	No
Characteristics of included studies provided.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FITT defined and examined in relation to outcome effect sizes.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scientific quality (risk of bias) of included studies assessed and documented.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Results depended on study quality, either overall, or in interaction with moderators.	Yes	Yes	Yes	No	Yes	Yes	No
Scientific quality used appropriately in formulating conclusions.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Data appropriately synthesized and if applicable, heterogeneity assessed.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Effect size index chosen justified, statistically.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Individual-level meta-analysis used.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Practical recommendations clearly addressed.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Likelihood of publication bias assessed.	No	No	No	No	No	No	No
Conflict of interest disclosed.	No	No	Yes	Yes	No	Yes	Yes

AMSTARExBP: SR/MA	Mehrholz, 2017	Phillips, 2011	Tse, 2017	Yang, 2012
Review questions and inclusion/exclusion criteria delineated prior to executing search strategy.	Yes	Yes	Yes	Yes
Population variables defined and considered in methods.	Yes	No	No	Yes
Comprehensive literature search performed.	Yes	Yes	Yes	Partially Yes
Duplicate study selection and data extraction performed.	Yes	No	Yes	No
Search strategy clearly described.	Yes	Yes	Yes	Yes
Relevant grey literature included in review.	Yes	Yes	No	No
List of studies (included and excluded) provided.	Yes	No	No	No
Characteristics of included studies provided.	Yes	Yes	Yes	Yes
FITT defined and examined in relation to outcome effect sizes.	No	N/A	No	N/A
Scientific quality (risk of bias) of included studies assessed and documented.	Yes	Yes	Yes	Yes
Results depended on study quality, either overall, or in interaction with moderators.	Yes	Yes	Yes	No
Scientific quality used appropriately in formulating conclusions.	Yes	Yes	Yes	Yes
Data appropriately synthesized and if applicable, heterogeneity assessed.	Partially Yes	N/A	Yes	N/A
Effect size index chosen justified, statistically.	Yes	N/A	Yes	N/A
Individual-level meta-analysis used.	No	N/A	No	N/A
Practical recommendations clearly addressed.	Yes	Yes	No	Yes
Likelihood of publication bias assessed.	No	No	No	No
Conflict of interest disclosed.	No	Yes	Yes	No

Appendices

Appendix A: Analytical Framework

Topic Area
Chronic Conditions

Systematic Review Questions
In individuals with a spinal cord injury, what is the relationship between physical activity and (1) risk of co-morbid conditions, (2) physical function, and (3) health-related quality of life?

Population
Individuals of all ages with a spinal cord injury

Exposure
All types and intensities of physical activity, including sedentary behavior

Endpoint Health Outcomes
- Risk of co-morbid conditions
- Physical function
- Health-related quality of life

Comparison
Individuals with a spinal cord injury who participate in varying levels of physical activity

Key Definitions
- Spinal cord injury refers collectively to damage incurred by the spinal cord resulting from trauma, disease, or degeneration and is marked by symptoms that vary according to the level (location) and severity of the injury. Source: World Health Organization. Spinal cord injury. World Health Organization website. http://www.who.int/mediacentre/factsheets/fs384/en. Accessed December 21, 2017.
- Risk of co-morbid conditions: The chance of having one or more additional conditions, including secondary conditions of medical, physiological, and other domains related to health-related quality of life.
- Physical function: "Physical function" and "physical functioning" are regarded as synonyms that refer to: "the ability of a person to move around and to perform types of physical activity."
    - For example, measures of physical function include measures of ability to walk (e.g., usually gait speed), run, climb stairs, carry groceries, sweep the floor, stand up, and bathe oneself. For individuals with spinal cord injuries, this includes physical performance capacities inclusive of strength and cardiorespiratory fitness levels.
    - As measures of behavioral abilities, physical function measures do not include:
        - Measures of the environment or of the host-environmental interaction (e.g., disability accommodation).
        - Measures of what a person usually does (e.g., physical activity level), as opposed to what a person is capable of doing.
- Health-related quality of life: "Health-related quality of life (HRQOL) is a multi-dimensional concept that includes domains related to physical, mental, emotional, and social functioning." Source: Healthy People 2020. Health-related quality of life & well-being. HealthyPeople.gov website. https://www.healthypeople.gov/2020/topics-objectives/topic/health-related-quality-of-life-well-being. Accessed December 21, 2017.

Appendix B: Final Search Strategy

Search Strategy: PubMed (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: PubMed; Date of Search: 8/10/17; 80 results

Set	Search Strategy
Limit: Language	(English[lang])
Limit: Exclude animal only	NOT ("Animals"[mh] NOT ("Animals"[mh] AND "Humans"[mh]))
Limit: Publication Date (Systematic Reviews/Meta-Analyses)	AND ("2011/01/01"[PDAT] : "3000/12/31"[PDAT])
Limit: Publication Type Include (Systematic Reviews/Meta-Analyses)	AND (systematic[sb] OR meta-analysis[pt] OR “systematic review”[tiab] OR “systematic literature review”[tiab] OR metaanalysis[tiab] OR "meta analysis"[tiab] OR metanalyses[tiab] OR "meta analyses"[tiab] OR "pooled analysis"[tiab] OR “pooled analyses”[tiab] OR "pooled data"[tiab])
Limit: Publication Type Exclude (Systematic Reviews/Meta-Analyses)	NOT (“comment”[Publication Type] OR “editorial”[Publication Type])
Physical Activity	AND (("Aerobic endurance"[tiab] OR "Bicycl*"[tiab] OR "Endurance training"[tiab] OR "Exercise"[mh] OR "Exercise"[tiab] OR "Exercises"[tiab] OR "Free living activities"[tiab] OR "Free living activity"[tiab] OR "Functional training"[tiab] OR "Leisure-time physical activity"[tiab] OR "Lifestyle activities"[tiab] OR "Lifestyle activity"[tiab] OR "Muscle stretching exercises"[mh] OR "Physical activity"[tiab] OR "Qi gong"[tiab] OR "Recreational activities"[tiab] OR "Recreational activity"[tiab] OR "Resistance training"[tiab] OR "Running"[tiab] OR "Sedentary lifestyle"[mh] OR "Speed training"[tiab] OR "Strength training"[tiab] OR "Tai chi"[tiab] OR "Tai ji"[mh] OR "Tai ji"[tiab] OR "Training duration"[tiab] OR "Training frequency"[tiab] OR "Training intensity"[tiab] OR "Treadmill"[tiab] OR "Walking"[tiab] OR "Weight lifting"[tiab] OR "Weight training"[tiab] OR "Yoga"[mh] OR "Yoga"[tiab]) OR (("Aerobic activities"[tiab] OR "Aerobic activity"[tiab] OR "Cardiovascular activities"[tiab] OR "Cardiovascular activity"[tiab] OR "Endurance activities"[tiab] OR "Endurance activity"[tiab] OR "Physical activities"[tiab] OR "Physical conditioning"[tiab] OR "Sedentary"[tiab]) NOT medline[sb]))
Population	AND ("Spinal cord injuries"[mh] OR "Spinal cord injuries"[tiab] OR "Spinal cord injury"[tiab] OR "Spinal cord trauma"[tiab] OR "Spinal cord traumas"[tiab] OR "Spinal cord laceration"[tiab] OR "Spinal cord lacerations"[tiab] OR "Traumatic myelopathy"[tiab] OR "Traumatic myelopathies"[tiab] OR "Post-traumatic myelopathies"[tiab] OR "Post-traumatic myelopathy"[tiab] OR "Spinal cord contusion"[tiab] OR "Spinal cord contusions"[tiab] OR

	"Quadriplegia"[mh] OR "Quadriplegia"[tiab] OR "Quadriparesis"[tiab] OR "Quadreparesis"[tiab] OR "Quadriplegic"[tiab] OR "Quadriplegics"[tiab] OR "Paraplegia"[mh] OR "Paraplegia"[tiab] OR "Paraparesis"[mh] OR "Paraparesis"[tiab] OR "Paraplegic"[tiab] OR "Paraplegics"[tiab])

Search Strategy: CINAHL (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: CINAHL; Date of Search: 8/10/17; 6 results
Terms searched in title or abstract

Set	Search Terms
Physical Activity	("Aerobic endurance" OR "Bicycl*" OR "Endurance training" OR "Exercise" OR "Exercises" OR "Free living activities" OR "Free living activity" OR "Functional training" OR "Leisure-time physical activity" OR "Lifestyle activities" OR "Lifestyle activity" OR "Muscle stretching exercises" OR "Physical activity" OR "Qi gong" OR "Recreational activities" OR "Recreational activity" OR "Resistance training" OR "Running" OR "Sedentary lifestyle" OR "Speed training" OR "Strength training" OR "Tai chi" OR "Tai ji" OR "Tai ji" OR "Training duration" OR "Training frequency" OR "Training intensity" OR "Treadmill" OR "Walking" OR "Weight lifting" OR "Weight training" OR "Yoga" OR "Aerobic activities" OR "Aerobic activity" OR "Cardiovascular activities" OR "Cardiovascular activity" OR "Endurance activities" OR "Endurance activity" OR "Physical activities" OR "Physical conditioning" OR "Sedentary”)
Outcomes	("Spinal cord injuries" OR "Spinal cord injury" OR "Spinal cord trauma" OR "Spinal cord traumas" OR "Spinal cord laceration" OR "Spinal cord lacerations" OR "Traumatic myelopathy" OR "Traumatic myelopathies" OR "Post-traumatic myelopathies" OR "Post-traumatic myelopathy" OR "Spinal cord contusion" OR "Spinal cord contusions" OR "Quadriplegia" OR "Quadreparesis" OR "Quadriparesis" OR "Quadriplegic" OR "Quadriplegics" OR "Paraplegia" OR "Paraparesis" OR "Paraplegic" OR "Paraplegics")
Systematic Reviews and Meta-Analyses	(“systematic review” OR “systematic literature review” OR metaanalysis OR "meta analysis" OR metanalyses OR "meta analyses" OR "pooled analysis" OR “pooled analyses” OR "pooled data")
Limits	2011–present English language Peer reviewed Exclude Medline records Human

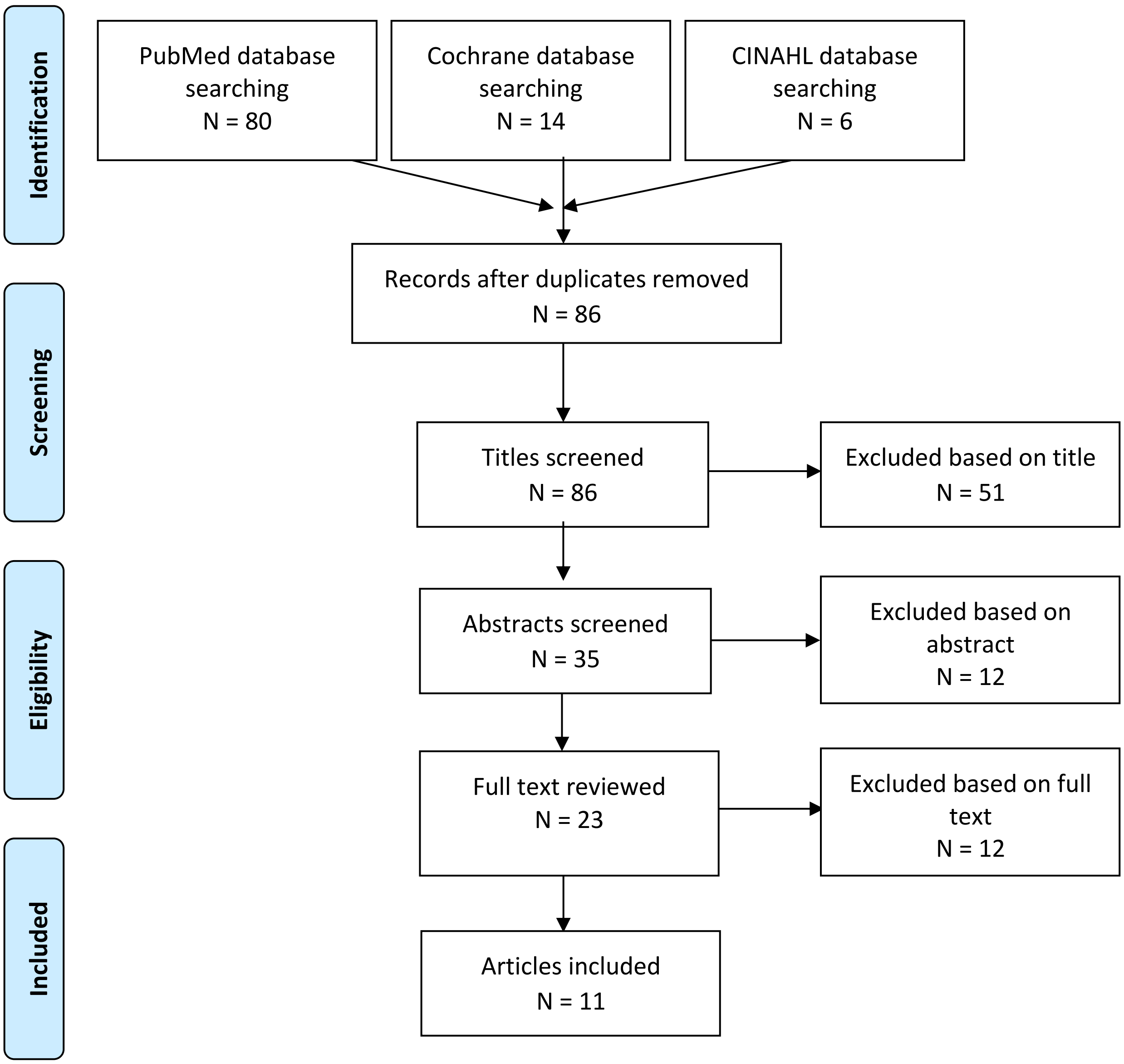
Search Strategy: Cochrane (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: Cochrane; Date of Search: 8/10/17; 14 results
Terms searched in title, abstract, or keywords

Set	Search Terms
Physical Activity	("Aerobic endurance" OR "Bicycl*" OR "Endurance training" OR "Exercise" OR "Exercises" OR "Free living activities" OR "Free living activity" OR "Functional training" OR "Leisure-time physical activity" OR "Lifestyle activities" OR "Lifestyle activity" OR "Muscle stretching exercises" OR "Physical activity" OR "Qi gong" OR "Recreational activities" OR "Recreational activity" OR "Resistance training" OR "Running" OR "Sedentary lifestyle" OR "Speed training" OR "Strength training" OR "Tai chi" OR "Tai ji" OR "Tai ji" OR "Training duration" OR "Training frequency" OR "Training intensity" OR "Treadmill" OR "Walking" OR "Weight lifting" OR "Weight training" OR "Yoga" OR "Aerobic activities" OR "Aerobic activity" OR "Cardiovascular activities" OR "Cardiovascular activity" OR "Endurance activities" OR "Endurance activity" OR "Physical activities" OR "Physical conditioning" OR "Sedentary")
Population	("Spinal cord injuries" OR "Spinal cord injury" OR "Spinal cord trauma" OR "Spinal cord traumas" OR "Spinal cord laceration" OR "Spinal cord lacerations" OR "Traumatic myelopathy" OR "Traumatic myelopathies" OR "Post-traumatic myelopathies" OR "Post-traumatic myelopathy" OR "Spinal cord contusion" OR "Spinal cord contusions" OR "Quadriplegia" OR "Quadreparesis" OR "Quadriparesis" OR "Quadriplegic" OR "Quadriplegics" OR "Paraplegia" OR "Paraparesis" OR "Paraplegic" OR "Paraplegics")
Limits	2011–present Word variations not searched Cochrane Reviews and Other Reviews

Appendix C: Literature Tree

Existing Systematic Reviews, Meta-Analyses, Pooled Analyses, and Reports Literature Tree



Appendix D: Inclusion/Exclusion Criteria

Chronic Conditions Subcommittee
Systematic Review Question: In individuals with a spinal cord injury, what is the relationship between physical activity and (1) risk of co-morbid conditions, (2) physical function, and (3) health-related quality of life?

Category	Inclusion/Exclusion Criteria	Notes/Rationale
Publication Language	**Include:** • Studies published with full text in English	
Publication Status	**Include:** • Studies published in peer-reviewed journals • Reports determined to have appropriate suitability and quality by PAGAC **Exclude:** • Grey literature, including unpublished data, manuscripts, abstracts, conference proceedings	
Research Type	**Include:** • Original research • Meta-analyses • Systematic reviews • Reports determined to have appropriate suitability and quality by PAGAC	
Study Subjects	**Include:** • Human subjects	
Age of Study Subjects	**Include:** • People of all ages	
Health Status of Study Subjects	**Include:** • Studies of people with a spinal cord injury • Studies of people with a spinal cord injury in combination with other chronic conditions reviewed on a case-by-case basis **Exclude:** • Studies that include people with a spinal cord injury as part of the study sample, but do not analyze results separately for people with a spinal cord injury	Spinal cord injuries include: spinal cord traumas, spinal cord lacerations, spinal cord contusions, (post-) traumatic myelopathies, quadriplegia, quadreparesis, paraplegia, paraparesis
Comparison	**Include:** • Adults who participate in varying levels of physical activity, including acute or chronic exercise or no reported physical activity • Recreational athletes (marathons ok as long as the study looks at a diverse group of runners—not just the elites)	

	Exclude: • High-performance athletes • Studies comparing athletes to non-athletes • Studies comparing athlete types (e.g., comparing runners to soccer players)	
Date of Publication	**Include:** • Systematic reviews, meta-analyses, pooled analyses, and reports published from 2011 to 2016	
Study Design	**Include:** • Systematic reviews • Meta-analyses • Pooled analyses • PAGAC-approved reports **Exclude:** • Randomized controlled trials • Prospective cohort studies • Narrative reviews • Commentaries • Editorials • Non-randomized controlled trials • Retrospective cohort studies • Case-control studies • Cross-sectional studies • Before-and-after studies	
Intervention/ Exposure	**Include studies in which the exposure or intervention is:** • All types and intensities of physical activity, including sedentary behavior • Studies with single, acute bouts of exercise as the exposure **Exclude:** • Studies that do not include physical activity • Studies where physical activity is used solely as a confounding variable • Studies of multimodal interventions that do not present data on physical activity alone • Studies of a disease-specific therapeutic exercise (e.g., rehabilitation) delivered by a medical professional (e.g., physical therapist) • Studies with measures of physical fitness as the exposure	
Outcome	**Include studies in which the outcome is:** • Risk of co-morbid conditions	

	• Physical function • Health-related quality of life	

Appendix E: Rationale for Exclusion at Abstract or Full-Text Triage for Existing Systematic Reviews, Meta-Analyses, Pooled Analyses, and Reports

The table below lists the excluded articles with at least one reason for exclusion, but may not reflect all possible reasons.

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
Adamson BC, Ensari I, Motl RW. Effect of exercise on depressive symptoms in adults with neurologic disorders: a systematic review and meta-analysis. *Arch Phys Med Rehabil.* 2015;96(7):1329-1338. doi:10.1016/j.apmr.2015.01.005.	X					
Boldt I, Eriks-Hoogland I, Brinkhof MW, de Bie R, Joggi D, von Elm E. Non-pharmacological interventions for chronic pain in people with spinal cord injury. *Cochrane Database Syst Rev*. 2014;(11):Cd009177. doi:10.1002/14651858.CD009177.pub2.	X					
Cheung EYY, Ng TKW, Yu KKK, Kwan RLC, Cheing GLY. Robot-assisted training for people with spinal cord injury: a meta-analysis. *Arch Phys Med Rehabil*. 2017;S0003-9993(17)30396-9. doi:10.1016/j.apmr.2017.05.015.				X		
Chilibeck PD, Guertin PA. Locomotor training and factors associated with blood glucose regulation after spinal cord injury. *Curr Pharm Des*. 2017;23(12):1834-1844. doi:10.2174/13816128226661612120546.	X					
Fekete C, Rauch A. Correlates and determinants of physical activity in persons with spinal cord injury: a review using the international classification of functioning, disability and health as reference framework. *Disabil Health J.* 2012;5(3):140-150. doi:10.1016/j.dhjo.2012.04.003.	X					
Galea MP. Spinal cord injury and physical activity: preservation of the body. *Spinal Cord*. 2012;50(5):344-351. doi:10.1038/sc.2011.149.			X			
Ginis KA, Hicks AL, Latimer AE, et al. The development of evidence-informed physical activity guidelines for adults with spinal cord injury. *Spinal Cord.* 2011;49(11):1088-1096. doi:10.1038/sc.2011.63.			X			
Gorski K, Harbold K, Haverstick K, Schultz E, Shealy SE, Krisa L. Locomotor training in the pediatric spinal cord injury population: a systematic review of the literature. *Top Spinal Cord Inj Rehabil*. 2016;22(2):135-148. doi:10.1310/sci2202-135.			X			

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
Jones ML, Evans N, Tefertiller C, et al. Activity-based therapy for recovery of walking in chronic spinal cord injury: results from a secondary analysis to determine responsiveness to therapy. *Arch Phys Med Rehabil*. 2014;95(12):2247-2252. doi:10.1016/j.apmr.2014.07.401.			X			
Lai B, Young HJ, Bickel CS, Motl RW, Rimmer JH. Current trends in exercise intervention research, technology, and behavioral change strategies for people with disabilities: a scoping review. *Am J Phys Med Rehabil*. 2017;96(10):748-761. doi:10.1097/PHM.0000000000000743.				X		
Mehrholz J, Kugler J, Pohl M. Locomotor training for walking after spinal cord injury. *Cochrane Database Syst Rev*. 2012;11:Cd006676. doi:10.1002/14651858.CD006676.pub3.				X		
Miller LE, Zimmermann AK, Herbert WG. Clinical effectiveness and safety of powered exoskeleton-assisted walking in patients with spinal cord injury: systematic review with meta-analysis. *Med Devices (Auckl).* 2016;9:455-466. doi:10.2147/MDER.S103102.				X		
Morawietz C, Moffat F. Effects of locomotor training after incomplete spinal cord injury: a systematic review. *Arch Phys Med Rehabil*. 2013;94(11):2297-2308. doi:10.1016/j.apmr.2013.06.023.				X		
Nash MS, Cowan RE, Kressler J. Evidence-based and heuristic approaches for customization of care in cardiometabolic syndrome after spinal cord injury. *J Spinal Cord Med*. 2012;35(5):278-292. doi:10.1179/2045772312Y.0000000034.			X			
Neefkes-Zonneveld CR, Bakkum AJ, Bishop NC, van Tulder MW, Janssen TW. Effect of long-term physical activity and acute exercise on markers of systemic inflammation in persons with chronic spinal cord injury: a systematic review. *Arch Phys Med Rehabil.* 2015;96(1):30-42. doi:10.1016/j.apmr.2014.07.006.	X					
Panisset MG, Galea MP, El-Ansary D. Does early exercise attenuate muscle atrophy or bone loss after spinal cord injury? *Spinal Cord*. 2016;54(2):84-92. doi:10.1038/sc.2015.150.	X					
Ravenek KE, Ravenek MJ, Hitzig SL, Wolfe DL. Assessing quality of life in relation to physical activity participation in persons with spinal cord injury: a systematic review.	X			X		

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
Disabil Health J. 2012;5(4):213-223. doi:10.1016/j.dhjo.2012.05.005.						
Silverman SR, Schertz LA, Yuen HK, Lowman JD, Bickel CS. Systematic review of the methodological quality and outcome measures utilized in exercise interventions for adults with spinal cord injury. *Spinal Cord*. 2012;50(10):718-727. doi:10.1038/sc.2012.78.	X			X		
Soleyman-Jahi S, Yousefian A, Maheronnaghsh R, et al. Evidence-based prevention and treatment of osteoporosis after spinal cord injury: a systematic review. *Eur Spine J.* May 2017. doi:10.1007/s00586-017-5114-7.				X		
van der Scheer JW, Martin Ginis KA, Ditor DS, et al. Effects of exercise on fitness and health of adults with spinal cord injury: a systematic review. *Neurology*. July 2017. doi:10.1212/WNL.0000000000004224.	X					
Warms CA, Backus D, Rajan S, Bombardier CH, Schomer KG, Burns SP. Adverse events in cardiovascular-related training programs in people with spinal cord injury: a systematic review. *J Spinal Cord Med.* 2014;37(6):672-692. doi:10.1179/2045772313Y.0000000115.	X					
Wiffen PJ. Systematic reviews published in the Cochrane Library January-March 2017. *J Pain Palliat Care Pharmacother*. 2017;31(2):167-169. doi:10.1080/15360288.2017.1314994.	X	X	X			
Wilroy J, Knowlden A. Systematic review of theory-based interventions aimed at increasing physical activity in individuals with spinal cord injury. *J Health Educ.* 2016;47(3):163-175. doi:10.1080/19325037.2016.1158673.				X		
Zwinkels, Verschuren M, Janssen O, Ketelaar TW, Takken M, T. Exercise training programs to improve hand rim wheelchair propulsion capacity: a systematic review. *Clin Rehabil*. 2014;28(9):847-861. doi:10.1177/0269215514525181.		X				

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2. Hicks AL, Martin Ginis KA, Pelletier CA, Ditor DS, Foulon B, Wolfe DL. The effects of exercise training on physical capacity, strength, body composition and functional performance among adults with spinal cord injury: a systematic review. *Spinal Cord*. 2011;49(11):1103-1127. doi:10.1038/sc.2011.62.

3. Phillips AA, Cote AT, Warburton DE. A systematic review of exercise as a therapeutic intervention to improve arterial function in persons living with spinal cord injury. *Spinal Cord*. 2011;49(6):702-714. doi:10.1038/sc.2010.193.

4. Bochkezanian V, Raymond J, de Oliveira CQ, Davis GM. Can combined aerobic and muscle strength training improve aerobic fitness, muscle strength, function and quality of life in people with spinal cord injury? A systematic review. *Spinal Cord*. 2015;53(6):418-431. doi:10.1038/sc.2015.48.

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