Public Health England

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Physical activity for general health benefits in disabled adults:

Summary of a rapid evidence review for the UK Chief Medical Officers' update of the physical activity guidelines

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Executive summary

Disabled people are twice as likely to be inactive when compared to non-disabled people. This report provides a review of the scientific evidence of the health benefits for physical activity specifically for disabled adults. It will inform the review of the UK Chief Medical Officers physical activity guildeines and also supported the first evidence-based physical activity infographic co-produced with health care professionals and people across a range of experiences of disability to address potential health benefits disabled adults can achieve by taking regular physical activity. The report also provides future research recommendations.

Evidence shows a relationship between engaging in physical activity and positive health outcomes for disabled adults. This report also provides suggestions on the amount of physical activity for health gains - the frequency, duration and intensity of physical activity that disabled people should undertake to benefit their health.

It is concluded that for substantial health gains disabled adults should do 150 minutes of physical activity at a moderate to vigorous intensity. They should also do 2 sets of challenging strength and balance exercises 2 times per week. Little evidence was found to show that physical activity is unsafe for disabled adults when it is performed at an appropriate dose for their current level of activity and health conditions.

Whilst the 2011 UK Chief Medical Officers' physical activity guidelines did not specicially consider disabled people, this report provides evidence that aligns with these guidelines. It also aids the implementation of the guidelines by providing an evidence base for disability groups, health and social care professionals and sport organisations to promote physical activity to disabled adults.

The evidence in this report was used to design an infographic on physical activity for disabled adults. The infographic was also co-produced with disabled people, health professionals and disability organisations to capture health benefits, dose-response physical activity relationships, affect, and concerns about sedentariness, making it the first of its kind.

Introduction

This report is about physical activity for health benefits among disabled adults. Whilst numerous definitions of disability exist across the globe, for the purpose of this report disability refers to people who have long term physical (e.g. spinal cord injury), sensory (e.g. visual impairment), cognitive (e.g. learning difficulties), and/or mental impairments (e.g. depression) which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others (1). Rather than focusing on just one impairment this review considers a range of impairments.

Promoting active lifestyles can help us address some of the important challenges facing the UK today. Physical inactivity is in the top ten greatest causes of ill health nationally, with negative impacts on health, wellbeing, social and economic outcomes for individuals and communities (2). Increasing and sustaining the physical activity levels of the population has the potential to improve the physical and mental health of the nation, improve quality of life, reduce all-cause mortality, and develop social cohesion. It can also deliver cost savings by reducing or preventing non-communicable diseases that destabilise the health and social care services (2).

Despite the benefits of physical activity, many adults across the UK are insufficiently active (2). One large group of the adult population that is particularly inactive is disabled people. Epidemiological data on physical activity demonstrate significant inequalities affecting this group. For example, in England disabled people are twice as likely to be inactive when compared to non-disabled people (2), with inactivity (less than 30 minutes per week) at 43% among disabled people and 21% for non-disabled adults (3). It is also reported that just 18% of disabled adults engage in at least one physical activity session per week compared to 41% of non-disabled adults (4). Moreover ‘inactive’ disabled people with 3+ impairments are more likely to be doing nothing than those with one or 2 impairments - meaning physical, cognitive, sensory, and/or intellectual impairments (3).

In 2011 the UK Chief Medical Officers' (CMOs) physical activity guidelines were produced. These outlined evidence-based, age-specific recommendations for physical activity for good health. The guidelines later led to the development of a series of infographics designed to translate physical activity recommendations and empower health professionals to promote physical activity behaviour change. However, with sparse evidence on disability at the time the guidelines and subsequent series of infographics did not address disabilities. The voices of disabled people were also not included during the creation of physical activity guidance and accompnying messaging. The 2011 guidelines and infographics are thus limited in their reference to how these apply and can be implemented by disabled people.

To address this, Public Health England (PHE) commissioned a review of the available evidence and, if sufficient, subsequently provide evidence-based recommendations in the form of an infographic. The review would thus offer the necessary scientific base to compare with evidence and recommendations outlined in the 2011 UK Chief CMOs physical activity guidelines, and the updated CMOs guidelines that will be published in 2019. The review would also build on and extend the Everybody Active, Every Day report (2014) (2) by PHE as well as other major reports, including the World Report on Disability by the World Health Organisation (2011) (5), Sport England's strategy for 2016–2021, Towards an Active Nation (2016) (6), HM Government strategy Sporting Future: A New Strategy for an Active Nation (7-8), and the US 2018 Physical Activity Guidelines Advisory Committee Scientific Report (9).

This report presents the findings from a rapid evidence review conducted to meet the following aims to:

1. Collate the evidence across different impairment groups on physical activity for health benefits in a single resource that can be used across the sector, including for public health messaging and by health care professionals, disability groups, sport organisations, and other relevant groups.

2. Compare the evidence with the recommendations for physical activity outlined in the UK CMOs adult guidelines

3. Produce evidence-based public health recommendations with disabled people and health care professionals on physical activity for disabled adults

4. Produce an evidence-base to underpin and inform the co-production of an infographic for carers, health and care practitioners, disabled people, disabled organisations, and sporting organisations with the view to facilitate implementation of CMOs physical activity guidelines and inform guideline updates in the future.

5. Identify gaps in the current evidence base.

Reviews on physical activity and disability certainly exist. One issue with available reviews, such as the US 2018 Physical Activity Guidelines Advisory Committee Scientific Report on physical activity (9), is that the review research team did not explicitly work with disabled people and user-organisations. Disabled people and disability organisations were not imcluded in the production of research questions, the identification of which research methods to include and exclude, and what future recommendations should be made, for example. The relevance of such reviews for disabled people and meaningfulness for improving their lives is thus not established.

Another common issue is that they attend one impairment group, such as spinal cord injury. Following consultation with over 10 UK disability organisations and over 300 disabled adults who have experienced one or more physical, cognitive, sensory, and mental impairment, there was strong consensus that any guidelines and ways to communicate these must be inclusive. By that it was meant that rather than focusing on one impairment group, a guideline should include all impairment groups. The adults with different impairments consulted strongly recommended that physical activity guidelines should not be concerned with one specific impairment group but instead should be aimed at disabled people in order to respect and promote inclusivity, connectivity, and strength in difference.

There was also strong consensus from the disability organisations and disabled people that the report and the messages should use disability first / social model language. That means ‘disabled people’ was the preferred language. It should be noted though that whilst ‘disabled people’ is often used across the UK other people prefer to describe themselves as a ‘person with a disability’ or an ‘individual with an impairment’. That should also be respected.

This research addresses these issues. It is the first to work with health professionals, disabled people, and disability organisations to provide evidence-based physical activity recommendations for good health for a range of experiences of disability - from physical impairments like spinal cord injury, amputee, and cerebral palsy, to sensory impairments like visual impairment and hearing impairment, to mental impairments like depression, and to cognitive impairments like learning difficulties, and from congenital to acquired impairments. The report also extends the reach of 2011 UK Chief CMOs physical activity guidelines by providing evidence on an adult population absent in these guidelines – that is disabled people. It can moreover be used in the future in updates of these guidelines.

Further research activity will be required to build on and consolidate the evidence and findings from this review. Future research recommendations presented herein are based on gaps in research evidence and were identified by disabled people as relevant and meaningful to them.

The review underpins and informs the construction of appropriate messages for an infographic focused on physical activity for disabled adults. This is the first evidence-based physical activity infographic specifically aimed at disabled people and health care professionals that has been co-produced with them and organisations to capture health benefits, dose-response physical activity relationships, affect, and concerns about sedentariness.

Methods

The evidence review utilised a rapid evidence review method to provide a systematic yet feasible search strategy to assess available evidence sources. Whilst a rapid review has fewer stages than a systematic review, available research has demonstrated that a rapid review produces similar conclusions to systematic reviews (10-12). Thus, although not as rigorous as a systematic review, a rapid review was chosen in light of research supporting its use and effectiveness to produce robust results (10-12). An a priori protocol, which was approved by experts, was established to ensure transparency and rigor. The protocol also provides a template from which the evidence base can build and evolve in subsequent years.

Protocol

The protocol used for this rapid review was informed by the Preferred Reporting Items for Systematic Reviews and Meta Analyses guidelines PRISMA-P (13).

Research questions

The team produced the research questions with disabled people and health care professionals through a series of consultations. Each question was discussed and refined for relevance for the potential for greatest public health impact and potential to inform public health policy and/or programmes. The formulation of questions was also facilitated by using two established frameworks: the Feasible, Interesting, Novel, Ethical, and Relevant (FINER) (14) framework and the Population, Intervention, Comparison/Control Group, Outcome, and Time (PICOT) (15) framework. The research questions approved were:

- question 1: What is the evidence that physical activity improves the health of disabled adults?
- question 2: What is known about the physical activity components of FITT (frequency, intensity, time and type) for disabled adults?
- question 3: Is physical activity safe for disabled adults?

Search strategy

A formal literature search, using bibliographic search databases, was the primary method of identifying evidence items. This electronic search covered the following databases: MEDLINE, Web of Science, Cinahl and SPORTDiscus. These databases were identified because they represented comprehensive repositories of citations, abstracts, and full articles in fields relevant to the research questions. The

databases were searched by two reviewers independently from the team using MesH terms and free text to capture relevant research. Core keywords used in the search included “Disability” or “Disabled Persons” or “Visual Impairment” or “Hearing Impairment” or “Cerebral Palsy” or “Spinal Cord Injury” or “Amputation” or “Amputee” or “Learning Disability” or “Intellectual Disability” or “Dwarfism” AND “Sport” or “Physical activity” or “Exercise” or “Fitness” or “Disabled sport”, AND “Congenital disability” or “Acquired disability”. The complete search strategy used in this study can be found in Appendix 1. A manual search for work on disability and physical activity, including the article reference lists, was also conducted by two of members of the team. Given the rapid nature of the review, the scope of the electronic and manual search included research from January 1st 2007 to February 17th 2018.

Inclusion and exclusion criteria

Inclusion and exclusion criteria used throughout the review were developed through discussion between the team, disabled adults, and health professionals. They were also guided by the PICOT framework. The criteria covered population (e.g. disabled adults only included), intervention/domain studied (e.g. physical activity), study type (e.g. randomised control trials published since 2007 included), geography (e.g. studies done in UK and comparable countries included), and relevance/outcome measures (e.g. cardiorespiratory fitness). It should be noted that mental impairments were not explicitly included in the search strings. There are already reviews suggesting there are positive benefits of physical activity for mental health outcomes for those with mental impairments (e.g.16-18). The rapidity of this review also precluded including mental impairment terms in the search. However, it should be noted that results of recent reviews were captured and compared with the evidence of each outcome for mental impairments with the evidence base for the other impairment groups. Recent reviews and hand searches also suggest that whilst mental health outcomes following physical activity for people with mental impairments is well reported, physical health outcomes are not well documented.

Searching and screening

Two team members independently searched the literature using four databases and the defined keywords. All citations identified in the search were independently screened by the reviewers on the basis of the title and the abstract to assess their match with inclusion criteria. The review team members also checked the references of included studies to identify any relevant papers not captured in the search. In accordance with recent recommendations for rapid reviews (11-12), a random sample of 20% citations identified were independently screened by a third reviewer and results compared. Disagreements regarding eligibility of studies were resolved by discussion and consensus.

A total of 1,414 items were identified through the electronic database search, and an additional 92 records were identified through manual searches. The manual search, or “hand search”, allowed for the identification of resources within impairment groups. The electronic and manual search resulted in a total of 1,506 items identified. Once duplicates were removed, the titles and abstracts of 1,120 records were screened, leaving 504 full-texts to be assessed for eligibility. Overall, 237 articles were included in the quantitative synthesis and 18 articles were included in the qualitative synthesis. Please see Appendix 3 for the PRISMA flow diagram. Please see Appendix 4 for a reference list of included papers that informed the review, and Appendix 5 for the primary research data. The global distribution of included articles can be seen in Figure 1.

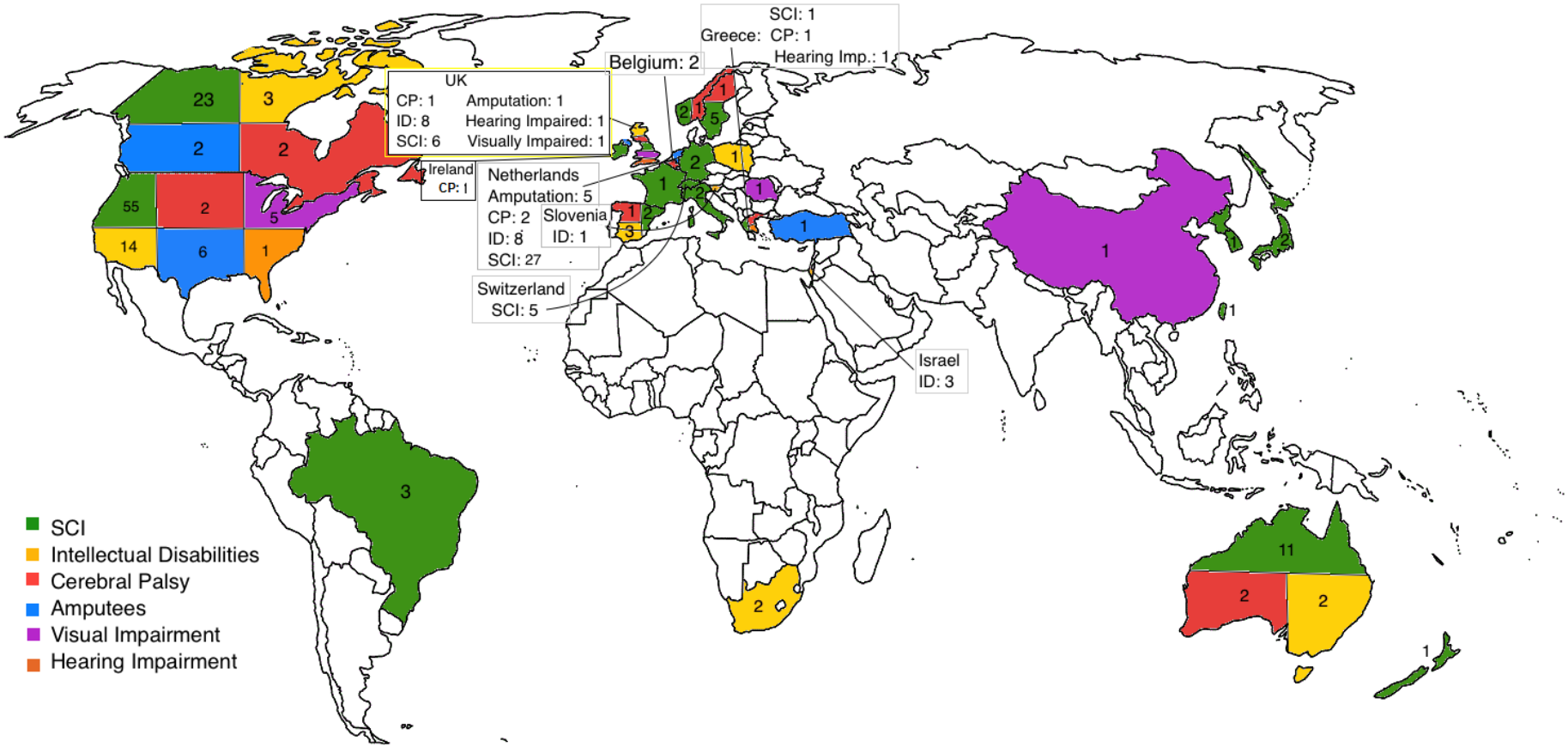


Figure 1. The global distribution of articles included in the rapid review by disability group

Data extraction

Data were extracted by the two reviewers after all relevant studies were screened and then selected. Information extracted from studies included the study design, disability group(s), country of study, and outcomes reported. Each reviewer checked the concordance of extraction. Any discrepancies were resolved through discussion. To minimise bias, and ensure the accuracy of the study selection procedure, a random sample of 20% of studies were independently extracted by a third reviewer and results compared.

Assessment strategy

Two independently reviewers graded all identified quantitative studies for the level of evidence each study provides. The criteria for each level of evidence was as follows:

Level 1 (High):	**Level 2 (Moderate):**	**Level 3 (Low):**
A control group was used	Pre-/post- and/or repeated measures design was used	Post-test only OR cross-sectional design was used
A pre-/post- or repeated-measures design was used	A control or comparison group may have been used, but was not required	Case Studies (individual or very small cohort)
Groups were randomised	Groups were not required to be randomised	Uncontrolled study
Example: Randomised Control Trial	A retrospective design may be used	A retrospective design may be used
	Examples: Cohort, Case-Control, Time Series studies	Example: Cross-sectional study

Due to qualitative studies providing different evidence, and qualitative research was deemed highly valuable by disabled people consulted, all identified qualitative studies were assessed for implementation (for example, what does a qualitative study tell us about physical activity in this group? What are the barriers to implementing physical activity for disabled people?).

The methodological quality of included studies was assessed independently by the two review members of the team using QATSDD (19). That tool was used as it is validated for assessing the quality of both quantitative and qualitative studies. That said, one measure on the QATSDD for qualitative research - inter-rater reliability - is flawed (20-21). It has been consistently shown to be ineffective and thus recommended to be no longer used for qualitative research (20-21). As such, inter-rater reliability was excluded from the assessment. A third reviewer independently assessed a random sample of 20% of the papers using the same assessment tool.

Concordance was checked and any discrepancies discussed and resolved. To further enhance the quality of this review, the team also compared all results with findings from extracted systematic reviews and key physical activity reports, including the 2018 USA Physical Activity Guidelines (9). The overall level and quality for studies specifically used to inform knowledge about FITT only is summarised in Figure 2.

Develop narrative summary

After the team members synthesised the results and developed concluding statements for each question, a narrative summary of the synthesis was crafted and research recommendations related to the questions produced. The research team coded the strength of the evidence for each outcome as green, amber, or red.

Green outcomes reflected a strong evidence base, that is, a body of research with both Level 1 and high quality evidence for a positive association with physical activity. Amber outcomes reflected a moderate evidence base; either because the evidence came from Level 2 studies, the studies were not high quality, or the evidence was equivocal i.e. studies showed mixed/contradictory results. Outcomes coded red, were studies where there was not enough evidence to make any statements regarding potential associations with physical activity.

The types of studies that thus provided strong evidence included randomised control trials (RCTs) that were assessed to also be of high quality. The types of studies that provided moderate and emerging evidence included RCTs that were of moderate quality as well as those as level 2 like case control studies that were of either high quality or moderate quality. Studies that were deemed low quality but still providing some evidence included cross sectional studies that were assessed to be of high or moderate quality. The outcomes of this assessment informed the recommendations within the results section. Qualitative studies of high quality provided contextual evidence about physical activity, such as the barriers and facilitators to being active, necessary for implementation purposes.

Figure 2. The level and quality of evidence of each study across impairment groups that informed the FITT principle

Level of Evidence

Quality of Evidence	1	2	3
High	SCI = 7 ID = 2 AMP = 1 CP = 1	SCI = 1 ID = 3 VIS = 1	SCI = 1 VIS = 1
Moderate	SCI = 10 ID = 5 VIS = 1 CP = 2	SCI = 19 ID = 9 VIS = 1 AMP = 2 HI = 1	SCI = 14 VIS = 1 AMP = 2 CP = 4
Low	SCI = 2 ID = 1 VIS = 1 AMP = 1	SCI = 11 ID = 1 CP = 1	SCI = 7 ID = 1 CP = 1

Key:

Spinal cord injury (SCI)
Intellectual disability (ID)
Amputee (AMP)
Cerebral Palsy (CP)
Visual impairment (VIS)
Hearing impairment (HI)

Results

The evidence used in this report is summarised in Appendix 5 of this report.

Question 1: What is the evidence that physical activity improves the health of disabled adults?

Answer at a glance:
Aligned with the 2011 the UK CMOs physical activity guidelines, there is sufficient evidence that supports the positive relationship and the effectiveness of physical activity to improve disabled adults health.

Overall, there is moderate to strong evidence that for disabled adults with physical and cognitive impairments physical activity is associated with increased cardiorespiratory fitness, improved muscular strength, improved functional skills, reduced disease risk and prevention, and improved psychosocial wellbeing and community. There is moderate to strong evidence that for disabled adults with mental impairments physical activity is associated with improved psychosocial wellbeing and community. There is however insufficient evidence for physical activity improving physical health for people with mental impairments. Whilst there is some evidence for physical activity improving mental health for people with sensory impairments, there are few high level studies that have examined physical activity and physical health benefits for this group of disabled people (see Appendix 5).

The review identified multiple outcomes associated with physical activity in the literature. To ensure consistency with the literature, it should be noted we extracted what the literature presented as potentially important outcomes. For example, if the literature identified ‘physical activity participation’ as an outcome that was identified as an outcome. We also use the same terminology the literature used to describe outcomes.

Specifically, for disabled adults with physical and cognitive impairments, notably among people with spinal cord injury (SCI) and intellectual disability, there is strong evidence for a positive association between physical activity and 15 outcomes: aerobic capacity, walking speed, muscular strength, muscular endurance, gait patterns, falls prevention, daily step count, moderate to vigorous exercise time, physical wellbeing, pain, balance, body composition, social development, quality of life, and community involvement. That evidence for physical and cognitive impairment groups is summarised in Figure 3.

As also summarised in Figure 3, there is moderate evidence for a positive association for these impairment groups between physical activity and 15 specific outcomes: exercising and resting heart rate, hypertrophy, speed, activities of daily living, mobility, physical activity participation, blood pressure, cholesterol levels, sedentary time, antioxidants, immune function, bone health, mental wellbeing and fatigue.

Among all impairment groups there was insufficient evidence to support an association between physical activity and 5 particular outcomes named in the literature: energy expenditure, motor skills, vascular health/function, economic development, and perceived health.

The ratings and conclusions pertaining to quality, level, and agreement of evidence for each of the sub-components of outcomes correspond with those reported in other recent reviews, and add to these (see Appendix 6 for examples).

Figure 3. A breakdown of the evidence for each major outcome group for physical and cognitive impairments

Cardiorespiratory Fitness	Muscular Strength	Functional Skills	Disease Risk and Prevention	Psychosocial Wellbeing and Community
Aerobic Capacity	Muscular Strength	Gait Patterns	Daily Step Count	Physical Wellbeing
Walking speed	Muscular Endurance	Falls Prevention	Moderate to Vigorous Exercise Time	Pain
Exercising and Resting Heart Rate	Hypertrophy	Balance	Body Composition	Social Development
Fuel Oxidation	Speed	Activities of Daily Living	Physical Activity Participation	Quality of Life
Energy Expenditure	Motor Skills	Mobility	Blood Pressure	Community Involvement
			Cholesterol Levels	Mental Wellbeing
			Sedentary Time	Fatigue & Energy Levels
			Antioxidants	Economic Development
			Immune Function	Perceived Health
			Bone Health	
			Vascular Health	

Conclusions

Evidence demonstrates that physical activity improve the health and reduces the risk of chronic diseases for disabled adults. Aerobic activities, like brisk walking, wheeling, swimming, jogging, dancing, cycling, playing basketball, rugby, football or tennis, and balance, stretching, and strength exercises, such as push ups, sit ups, working with a resistance band, and weight training, are recommended for health benefits.

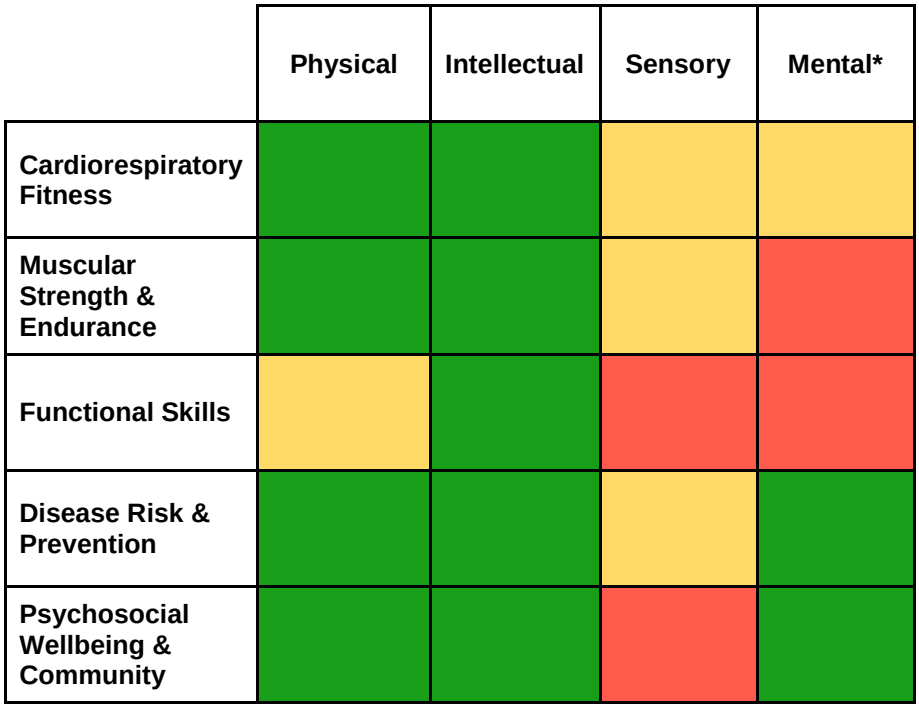
Question 2: What is known about the physical activity components of FITT for disabled adults?

Answer at a glance:
For substantial health gains, and aligned with the 2011 The UK CMOs physical activity guidelines, the evidence suggests that disabled adults should do between 120 and 180 minutes of physical activity at a moderate to vigorous intensity plus do 2 sets of challenging strength and balance exercises twice per week.

There is also evidence that disabled adults can accrue health benefits when they engage in physical activity at a lower intensity and duration, but these benefits are not as large when activity is performed at a higher intensity and duration. Thus, whilst something is better than nothing, more is better.

There is evidence for the physical activity components of FITT (Fitness, Intensity, Time and Type) for disabled adults. The evidence is however largely based on studies made up first of people with physical impairments, notably individuals with SCI, and second people with intellectual impairments. The distribution of the evidence among the four main groups of impairments (physical, intellectual, sensory, and mental) is displayed in Figure 4.

Figure 4. A breakdown of the evidence for each major impairment group



*Evidence base estimated from results of recent reviews

Cardiorespiratory fitness

The total number of studies reviewed for this outcome was 56. Twenty two of these studies were ranked green (either high or moderate quality RCT's or high quality cohort studies). There is thus strong evidence from a large number of high quality studies that physical activity is associated with cardiorespiratory fitness among adults with physical and intellectual impairments. There is moderate evidence from cohorts with sensory and mental impairments.

Available evidence suggests that 30 to 45 minutes of moderate to vigorous physical activity (60-80%HR max) 2 to 3 times per week, or 60 to 90 minutes of low to moderate (45-65%HR max) intense physical activity 2 to 3 times per week, will be effective for cardiorespiratory fitness benefits. There is also evidence, albeit lower quality, which suggests that 30 to 60 minutes of low to moderate intensity activity 2 to 3 times a week may be effective for fitness gains.

Muscular strength

The total number of studies reviewed for this outcome was 36. Thirteen of these studies were ranked green. There is thus strong evidence that strength training leads to improvements in muscle strength among adults with physical and intellectual impairments. There is moderate evidence from studies including adults with sensory disabilities, and little evidence from studies including adults with mental impairments.

Available evidence suggests that for substantial health gains adults should do 3 sets of 10-15 reps of a challenging but manageable load targeting large muscle groups 3 times per week. There is also moderate evidence that benefits for strength can be gained by doing 3 sets of 10-12 reps of strength activities twice per week at a challenging but manageable load.

Functional skills

The total number of studies reviewed for this outcome was 15. Nine of these studies were ranked green. There is strong evidence for disabled adults with intellectual disabilities that physical activity is associated with improved functional skills, such as tasks like getting out bed, cooking, housework, and gardening. There is moderate evidence for these benefits from disabled adults with a physical impairment. There is little research on cohorts with sensory and mental impairments.

Available evidence suggests that 40 to 60 minutes of moderate to vigorous physical activity (60-80%HR max) 2 to 3 times per week, or 60 to 90 minutes of low to moderate (45-65%HR max) intense activity 2 to 3 times per week will be effective

for functional gains. There is also moderate evidence that benefits for functional skills can be gained by doing 30 to 60 minutes of low to moderate intense activity, 2 to 3 times per week.

Disease risk and prevention

The total number of studies reviewed for this outcome was 58. Seventeen of these studies were ranked green. There is strong evidence for a positive association between physical activity and cardio-metabolic health for disabled adults with physical, intellectual and mental impairments, with higher doses of physical activity associated with higher levels of cardiovascular and metabolic health. There is a moderate evidence base for adults with sensory impairments.

The available evidence suggests that for these health benefits adults should do 45 to 60 minutes of moderate to vigorous physical activity (60-80%HR max) twice per week, or 45 to 60 minutes of low to moderate (45-65%HR max) intense activity a minimum of 3 times per week.

Psychosocial wellbeing and community

The total number of studies reviewed for this outcome was 37. Twenty four of these studies were ranked green. There is strong evidence that physical activity is associated with improved wellbeing and community involvement among disabled adults with physical, intellectual, and mental impairments. There is little quantitative evidence from cohorts with sensory disabilities.

Available evidence suggests that 45 to 60 minutes of low to moderate (45-65%HR max) intensity activity twice per week will be effective for wellbeing and community benefits. Sufficient evidence also suggests that improvements in quality of life will be maximised with further increases in frequency and intensity.

Type and promotion of physical activity

Examples of physical activities included in studies were hand cycling, functional electrical stimulation (FES) assisted exercise, modified ergometers (cycle, rowing, kayak), resistance bands, free weights, resistance exercise machines, circuit training, arm crank exercises, dancing, martial arts, modified sports (rugby, basketball, jiu-jitsu, tennis), locomotor or gait training, aquatic exercise, functional activities (grocery shelving, sit-to-stand), proprioceptive activities, fall prevention, and balance exercises.

Through such physical activities a range of both cardiovascular and resistance training modalities were effective for health benefits. Disabled adults should

therefore choose their type of activity with their own needs and interests in mind. The safety of the type of activity and intensity of it should also be considered. If in doubt a health care professional should be consulted. An exercise type that allows the individual to develop is also recommended (e.g. adding load to resistance machines, or improving the speed at which they can cover a set distance). Emerging evidence suggests that regular guidance and prompting from a health care professionals, peer support, motivational interviewing, goal setting, action planning, the addition of music during physical activity, take home instructional videos, and training positive attitudes towards physical activity can be effective for helping disabled adults start physical activity and sustain an active lifestyle.

Importantly, evidence suggests that activities an individual enjoys and at an intensity which makes them feel good are likely to more effective in getting inactive people active and creating long term physical activity habits. Whilst affect is frequently a missing ingredient in the promotion of physical activity, there is now quantitative and qualitative evidence (23-27) that highlights the importance of fun, pleasure, and feeling good in starting and maintaining physical activity.

Conclusions

Based on the available evidence, it is concluded that:

Disabled adults do 2 sets of challenging strength and balance activities at least 2 times per week.

Whilst some physical activity is better than nothing, for substantial health gains disabled adults should engage in 150 minutes of physical activity per week at a moderate to vigorous intensity. This conclusion is aligned with the 2011 UK CMOs physical activity guidelines, thereby further minimising any possible confusion about physical activity for substantial health benefits.

Affect is foregrounded when promoting physical activity. That can be done by emphasising pleasure and enjoyment through, for example, messages like ‘Physical activity makes you feel good’ and ‘Enjoy what you do’.

Guidance is needed for people to measure simply intensity themselves. That is because people can find it challenging to measure their own intensity of activity. To help with this and provide more clarification, simple measures that can be used in everyday life, like the talk test, are effective. The talk test is a simple way to measure relative intensity. In general, if a person is doing moderate-intensity activity they can talk, but not sing, during the activity. If they are doing vigorous-intensity activity, they cannot say more than a few words without pausing for a breath. Like

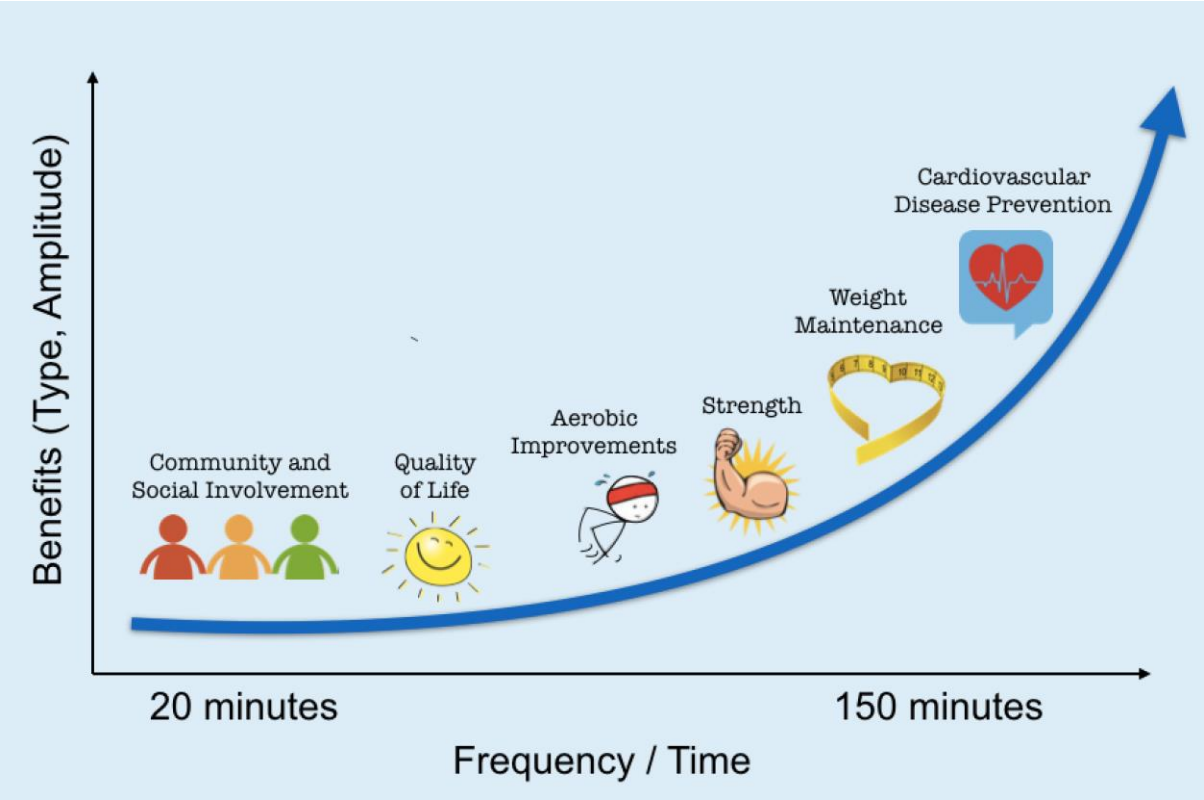
affect, it is concluded that a simple measure of intensity, such as the talk test, is included in an infographic promoting physical activity.

Messages in relation to the consequences of sedentary behaviour should be clear. Any message produced about sedentary behaviour must though avoid what is known as ableism. Ableism denotes the discrimination in favour of ‘able-bodied’ people and, likewise, the discrimination against disabled people. In terms of sedentary behaviour, ableism can take the form of messages like ‘Stand up, sit less’ or ‘Sit less, move more’. These messages favour certain bodies (e.g. those that can stand or easily avoid sitting) whilst discriminating against other kinds of bodies (e.g. those who need to sit in a wheelchair due to a spinal cord injury). Ableism is often unintentional and most people are completely unaware of the impact of their words or actions. But ableism is still a form of discrimination and should be avoided. It is thus recommended that rather than messges like ‘Sit less, move more’, messages like ‘Don’t be still for too long’ are used.

In the future, it is also concluded that there is an emphasis on the dose-response relationship of physical activity and benefits to health. It is suggested that the health benefits of engaging in physical activity for a lower amount of time than 150 minutes is communicated in guidelines and messages. That suggestion is based on the evidence presented. The evidence suggests there are some health benefits of engaging in physical activity for, for example, 60 minutes at a moderate to vigorous intensity per week for disabled adults.

Disabled adults and health care professionals involved in the review also suggested emphasising the dose-response relationship of physical activity and benefits to health. The reason frequently given for this was that the 150 minute message puts disabled adults who are inactive or intending soon to be active off from engaging in physical activity. Emphasing the benefits of engaging in physical activity for 60 minutes, for example, would however be a more realistic target. It would likewise be a more motivating message for behaviour change. Thus, an emphasis on the dose-response relationship of physical activity and benefits to health could produce wider public health benefits and have greater impact than just one touch point – that is, 150 minutes per week. An example is provided in Figure 5.

Figure 5. The multi-faceted dose-response curve of exercise



Question 3: Is physical activity safe for disabled adults?

Answer at a glance:
There is no evidence that unsupervised physical activity at the appropriate intensity is a risk for disabled adults. Physical activity should be progressive, building up first in frequency and duration and then later raising intensity, especially for inactive disabled people and those with existing health conditions.

Based on the reviewed studies, it can be said that there is no good evidence base that suggests appropriate physical activity is a risk for disabled adults. In contrast, the risks of poor health as a result of inactivity are high. This evidence is aligned with the 2011 UK CMOs physical activity guidelines.

Of course, for anyone there are always potential risks when engaging in physical activity. The potential risks identified in the review, especially those who are inactive, are shown in Figure 5. They include:

Adverse dose response to protocol/equipment. This may arise when engaging in a research study, or using physical activity equipment unsupervised after being inactive for long periods. Potential adverse effects include symptoms of orthostatic hypotension upon standing, lower extremity pressure ulcers from support harnesses or functional electrical stimulation assisted exercise, and skin lesions or rashes. It is recommended that upon starting a training programme, especially following a long period of inactivity, advice from a trained professional is sought to minimise any potential of risk.

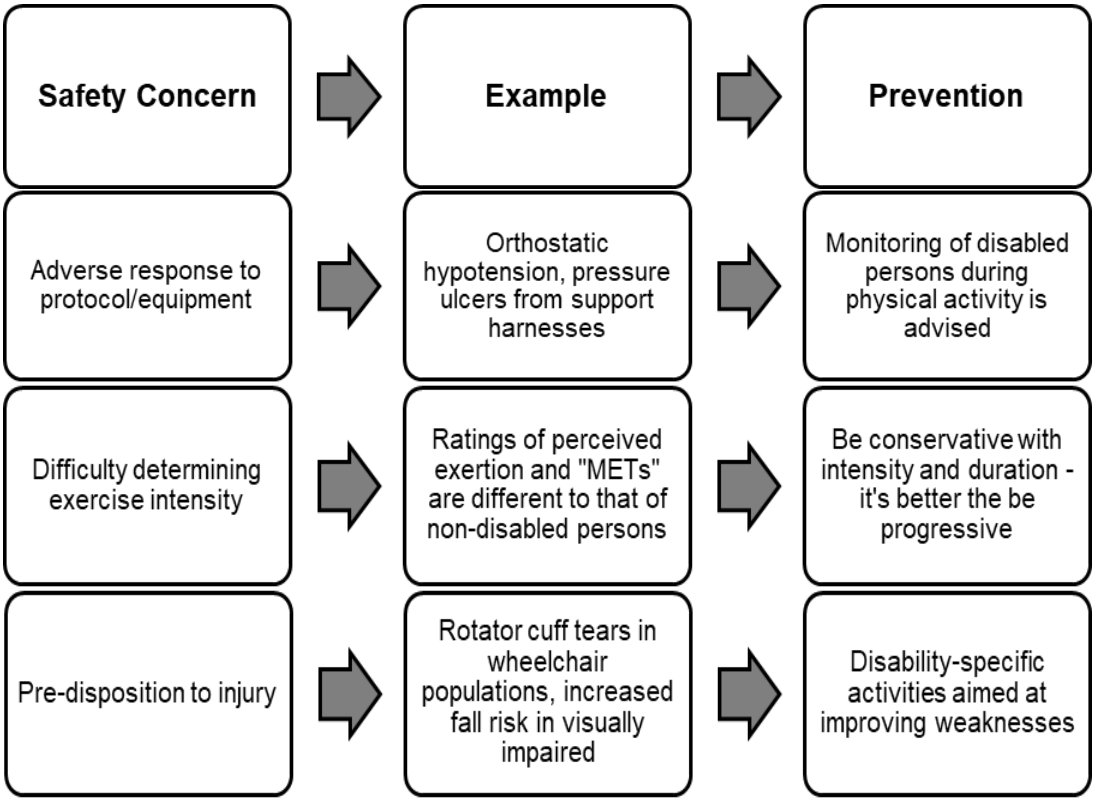
Pre-disposition to injury. Wheelchair users who participate in upper extremity activity and overhead-sports are at risk of rotator cuff tears. To minimise that risk it is recommended that strengthening exercises that focus on large muscle groups of the arm and shoulder are built into any exercise programme for wheelchair users who aim to participate in upper extremity activities or overhead-sport. The reason for this is that evidence shows that circuit resistance training for wheelchair users significantly improves muscular endurance, strength, and anaerobic power while decreasing self-reported shoulder pain.

Difficulty determining exercise intensity. Evidence suggests the metabolic equivalent of tasks (METs) or RPE are not accurate ways for untrained or inactive disabled adults to determine an optimal level of intensity for health benefits. This however is not to recommend that METs or RPE should be avoided when working with adults with different impairments. Health profressionals consulted find the RPE useful in, for example, rehabilitation contexts with disabled adults. The RPE is also often deemed by reserachers to be the most useful solution at present for examining

exercise intensity among disabled adults. That recognised, if physical activity is too intense when untrained or inactive there is still the potential of risk of injury. Although the safest method of increasing one's physical activity intensity has not been empirically established, for individuals who have been performing little or no moderate-to-vigorous physical activity, adding a small and comfortable amount of light- to moderate-intensity activity, such as walking or wheeling an additional 5 to 15 minutes 2 to 3 times per week, has a low risk of musculoskeletal injury and no known risk of sudden severe cardiac events. As also recommended in the US 2018 Physical Activity Guidelines (8) frequency and duration should be increased before raising the intensity. That message is particularly important for inactive disabled adults with a pre-existing health conditions, use medication, or are susceptible to secondary health conditions like autonomic dysreflexia.

Conclusions

Figure 6. The 3 main safety concerns identified from the included articles, including specific examples and proposed prevention measures to minimise risk



Based on the available evidence, there are no major risks of engaging in physical activity when it is performed at an appropriate level of duration and intensity for the individual. That recommendation is aligned with advice in the 2011 UK CMOs physical activity guidelines.

Research gaps

Disability and physical activity scientific evidence is accumulating. At the same time, important gaps in knowledge remain. Based on identified gaps in research and priorities identified by people with physical, sensory, intellectual and cognitive impairments, six areas are highlighted where more research would help in drawing conclusions, they are:

1. Evidence on physical activity and health outcomes for disabled children and youth.
2. More information that emphasises the dose-response relationship of physical activity and benefits to health so that people have attainable targets, especially for disabled adults who are inactive or intending soon to be active.
3. Determine the role of sedentariness (i.e., low energy-expending waking behaviour while seated or lying down) on multiple health outcomes in disabled people.
4. Expand knowledge on the impact of health inequalities on physical activity participation among disabled people.
5. Develop quality instrumentation and data collection systems that will enhance surveillance systems for detecting and responding to the physical activity needs of disabled people.
6. Develop theoretically-based and co-produced interventions to enhance disabled people’s quality and quantity of physical activity participation over the life course.

To fill this research gap, public health bodies, university researchers, funding communities, disability communities, and relevant sport and disability organisations should work together. This would avoidduplication of work, ensure best practice is shared, and facilitate research that is both of high quality and can have major impact.

Disabled people are often oppressed and discriminated against. Individual behaviours, including physical activity behaviours, are determined not solely by individual choice but by disablism, ableism, health inequalities, and other social, cultural, economic, and environmental factors that restrict significantly what disabled can do, could do, and might become. These factors also need to be foregrounded much more in research and implementation of evidence so that change can happen. They can provide the necessary foundation for public health agencies, health care professionals, disability groups, and sport organisations to promote physical activity to disabled people

Despite the expansion of evidence, and evidenced benefits of physical activity for health, more work is needed on physical activity, disability and health if we are full realise the potential of being active, more often for people with different impairments across the UK. Too often this is hampered by silo work. What is thus important for realising the potential of being active, more often for health is the need for public health bodies, university researchers, funding communities, disability communities, and relevant sport and disability organisations to *all* work closely together.

Summary

This review provided a detailed overview of the existing evidence base on physical activity for health benefits for disabled adults. There is evidence for a positive relationship and the effectiveness of physical activity to improve disabled adults health. Aligned with the 2011 UK CMOs physical activity guidelines, based on this review of evidence it is recommended that some physical activity is better than nothing, but for substantial health gains disabled adults should engage in 150 minutes of physical activity at a moderate to vigorous intensity per week. They should also do challenging strength and balance exercises on at least 2 days per week. With respect to safety, no evidence exists that suggests appropriate physical activity is a risk for disabled adults.

It would seem therefore that for disabled adults there are analogous health benefits of engaging in physical activity as for the rest of the adult population. Any myths about physical activity being inherently harmful for disabled people should also be dispelled.

The main strengths of this report is that they have focused on physical activity in a population not represented in previous UK guidelines, that is, disabled adults. They were also co-produced with disabled adults and organisations. That is another first. The review is also timely in that it can inform the forthcoming CMOs adult physical activity guidelines, which are currently being updated and will be published in 2019. In informing these guidelines, for the first time disabled people will be explicitly recognised in physical activity recommendations for adults.

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Appendix 1

Search strings

	MEDLINE (Ovid)	Web of Science	CINAHL	SportDISCUS
1	(Disabled Persons or Amputees or Mentally Disabled Persons or Visually Impaired Persons or Persons with Hearing Impairments or Learning Disorder* or Intellectual Disabilit* or Dwarfism or Cerebral Palsy or Spinal Cord Injur*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms)	TS=(“Disabled Persons” OR “Persons with Disabilities” OR "Visual Impairment" OR "Hearing Impairm*" OR "Cerebral Palsy" OR "Spinal Cord Injur*" OR Amput* OR "Learning (Disability OR Impairment)" OR “Mentally Disabled” OR Intellectual Disabilit* OR Dwarfism)	TI OR AB (MH "Hearing Disorders") OR (MH "Vision Disorders") OR (MH "Cerebral Palsy") OR (MH "Spinal Cord Injuries") OR (MH "Amputation") OR (MH "Developmental Disorders") OR (MH “Learning Disabilities”) OR (MH "Dwarfism") OR Disabled persons	TI OR AB (MH "Hearing Disorders") OR (MH "Vision Disorders") OR (MH "Cerebral Palsy") OR (MH "Spinal Cord Injuries") OR (MH "Amputation") OR (MH "Developmental Disorders") OR (MH “Learning Disabilities”) OR (MH "Dwarfism") OR Disabled persons
2	(Sport or	TS=(Sport or	TI OR AB ((Hearing	TI OR AB ((Hearing

	Sports or Physical Activity or Exercise or Physical Fitness or Leisure Activities or Motor Activity or Athlete* or Disabled Sport* or Disability Sport).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms)	Sports or “Physical Activity” or Exercise or Physical Fitness or “Leisure Activities” or “Motor Activity” or Athlete* or “Disabled Sport*” or “Disability Sport”)	(Disorders OR Impairment)) OR (Vision (Disorders OR Impairment)) OR "Cerebral Palsy" OR "Spinal Cord Injur*" OR Amput* OR Dwarfism OR (mental disabilit* OR learning disabilities or intellectual disabilities or learning difficulties or special needs))	(Disorders OR Impairment)) OR (Vision (Disorders OR Impairment)) OR "Cerebral Palsy" OR "Spinal Cord Injur*" OR Amput* OR Dwarfism OR (mental disabilit* OR learning disabilities or intellectual disabilities or learning difficulties or special needs))
3	1 and 2	1 and 2	1 or 2	1 or 2
4	(Cardiorespiratory Fitness or FITT or MET or Intensity or Muscle Strength or Bone Strength or Oxygen Consumption or Heart Rate or Balance or Flexib* or Steps or Body Composition or Power Output	TS=(Cardiorespiratory Fitness or FITT or MET or Intensity or Muscle Strength or Bone Strength or Oxygen Consumption or Heart Rate or Balance or Flexib* or Steps or Body Composition or Power Output or Endurance or Cardiometabolic or Lipid Profile* or	TI OR AB ((Sport OR Sports OR Physical Activity OR Exercise OR Physical Fitness OR Leisure Activities OR Motor Activity OR Athlete* OR Disabled Sport* OR Disability Sport OR Physical education & training))	TI OR AB ((Sport OR Sports OR Physical Activity OR Exercise OR Physical Fitness OR Leisure Activities OR Motor Activity OR Athlete* OR Disabled Sport* OR Disability Sport OR Physical education & training))

	or Endurance or Cardiometaboli c or Lipid Profile* or Cardiovascular Risk or Sedentary or morbidity or health outcomes).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms)	Cardiovascular Risk or Sedentary or morbidity or health outcomes)		
5	(Wellbeing or (Quality adj2 Life) or Self Esteem or Confidence or Pleasure or Fun or Happiness or Personal Development or Community Development or Safe*).mp. [mp=title, abstract, original title, name of substance word, subject	TS=(Wellbeing or (Quality NEAR2 Life) or Self Esteem or Confidence or Pleasure or Fun or Happiness or Personal Development or Community Development or Safe*)	TI or AB (("Cardiorespiratory Fitness" or FITT or MET or Intensity or "(Muscle or Bone) Strength" or "Oxygen Consumption" or "Heart Rate" or Balance or Flexib* or Steps or "Body Composition" or "Power Output" or Endurance or Cardiometabolic or "Lipid Profile*" or "Cardiovascular Risk" or Sedentary or morbidity or "health outcome") OR (Wellb eing or (Quality N2 Life)	TI or AB (("Cardiorespiratory Fitness" or FITT or MET or Intensity or "(Muscle or Bone) Strength" or "Oxygen Consumption" or "Heart Rate" or Balance or Flexib* or Steps or "Body Composition" or "Power Output" or Endurance or Cardiometabolic or "Lipid Profile*" or "Cardiovascular Risk" or Sedentary or morbidity or "health outcome") OR (Wellb eing or (Quality N2 Life)

	heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms)		or Self Esteem or Confidence or Pleasure or Fun or Happiness or Personal Development or Community Development or Safe*))	or Self Esteem or Confidence or Pleasure or Fun or Happiness or Personal Development or Community Development or Safe*) NOT (Pediatric* OR Child*)
6	4 or 5	4 or 5	3 and 4 and 5	3 and 4 and 5
7	3 and 6	3 and 6		
8	limit 7 to (english language and humans and "core clinical journals (aim)" and yr="2007 - Current" and "all adult (19 plus years)" and "core clinical journals (aim)" and english and humans and (adaptive clinical trial or clinical study or clinical trial, all or clinical trial or comparative study or controlled clinical trial or journal article or meta analysis or observational study or randomized controlled trial or "review" or systematic	Refined by: Categories: (Rehabilitation Or Sport Sciences Or Clinical Neurology Or Neurosciences Or Education Special Or Orthopedics Or Physiology Or Public Environmental Occupational Health Or Health Policy Services Or Medicine Research Experimental Or Health Care Sciences Services Or Psychiatry Or Cardiac Cardiovascular Systems) And Document Types: (Article Or Review) And Countries/Regions: (Usa Or Ireland Or Canada Or Netherlands Or Australia Or North Ireland Or England Or Wales Or	Limit search to adults, 1 Jan 2007-Feb 2018, English language, research article and peer reviewed	

	reviews) and medline)	Switzerland Or Sweden Or Scotland Or New Zealand Or Norway) And Language: (English) *And* Document Types: (Article Or Review)		
				Limiters - Published Date: 20070101-20181231; Language: English;

Appendix 2

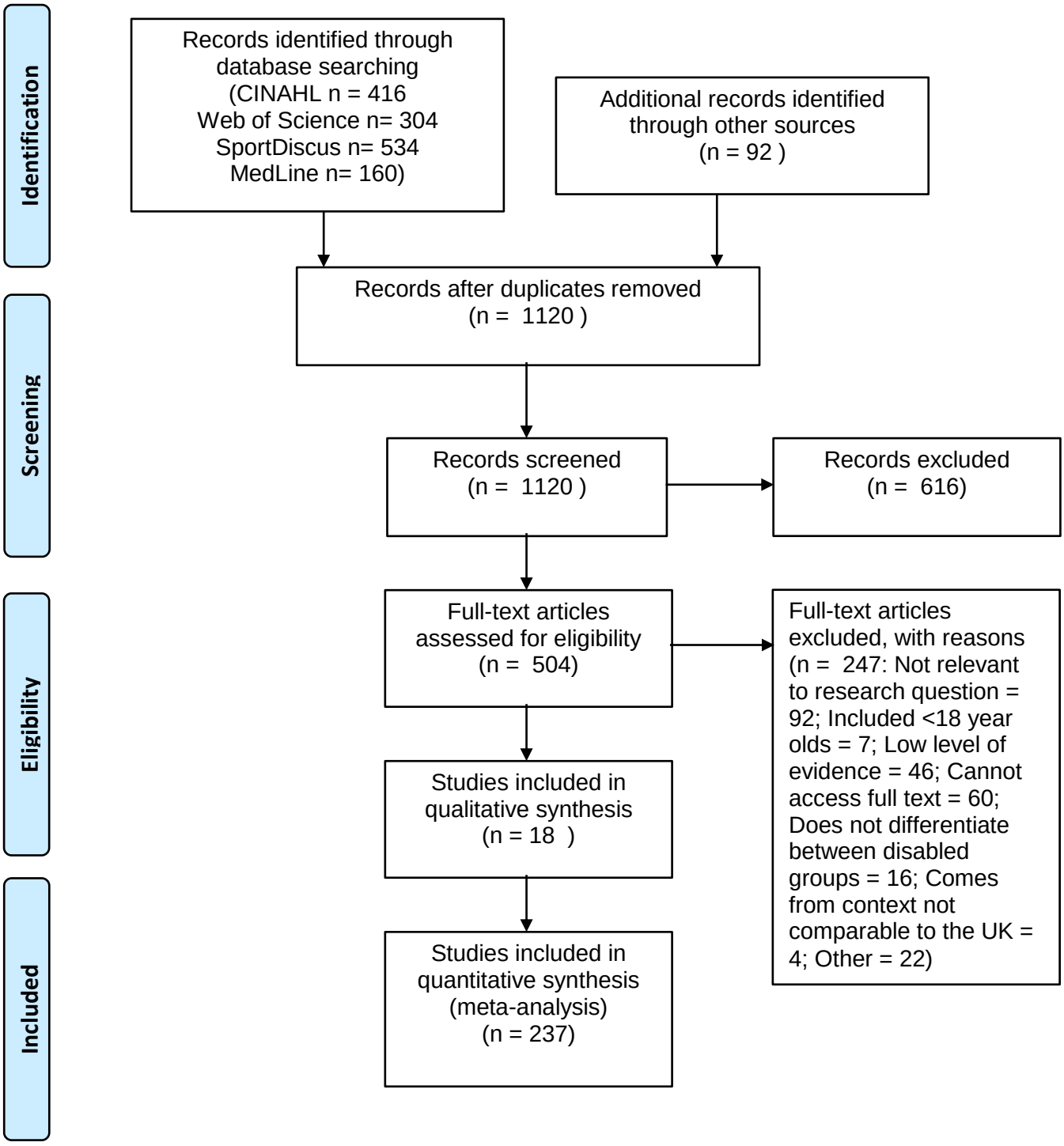
Inclusion and exclusion criteria

	Include:	Exclude:
Population	• Disabled people aged 18+, including people with visual impairments, hearing impairments, cerebral palsy, SCI, amputation, restricted growth or learning and intellectual disability, or a combination of any of the disabilities. • People with congenital and acquired physical or cognitive impairments.	• Participants under the age of 18. • Samples that include both non-disabled and disabled people and do not identify differences in outcomes between the two groups. • Studies simply focusing people with mental illness.
Intervention / Domain studied	• Research focused solely on physical activity, sport, sports participation, exercise, fitness, disabled sport or any equivalent.	
Study type	• Research articles written in English. • Research published since 2007 up until February 2018. • Systematic reviews, meta-analyses, randomised controlled trials (RCTs), cohort studies, time-series study, case control studies, cross-sectional studies, and qualitative studies. • Items in a peer-reviewed journal prioritised, followed by government reports and grey literature.	• Research articles not produced in English. • Studies published only in abstract format. • Studies, published in books, book chapters, comments, posters or letters. • Studies published outside the time frame of the rapid review (2007-2018).
Geography	• UK items prioritised. • Non UK items included where they a) cover outcome areas or the domain studied where UK evidence is lacking and b) come from contexts that are comparable to the UK.	• Research studies that come from contexts that are not comparable to the UK.
Relevance (outcomes measures)	• Physical activity/exercise time (time); Steps taken/distance (time); Muscle and bone strength (intensity and type); Fitness (Cardiorespiratory	

	fitness, power output, muscle strength); Cardiometabolic health (Body composition, cardiovascular risk); Metabolic equivalent of task; Oxygen consumption; Heart rate; Flexibility; Balance; HIIT; Sedentary time; Mental wellbeing; Physical wellbeing; Individual development; Social and community development; Economic development.

Appendix 3

PRISMA flow diagram



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Appendix 5

Primary research data

Key:
CP=cerebral palsy
SCI=spinal cord injury
ID=intellectual disability,
RCT=randomised controlled trial
QoL=quality of life
PA=physical activity,
LTPA=leisure-time physical activity
1RM=one repetition maximum
BMI=body mass index
RPE=rate of perceived exertion
FES=functional electrical stimulation
MET=metabolic equivalent of task
RoM=range of motion.

Author (date), country	Study type (size) & population	Quality Assessment	Outcomes measured: [O: objective; S: subjective]	Aims	Key Findings
AMPUTEES					
Desveaux (2016), Canada [61]	Cross-sectional (15), older adults, mostly male	Mod	Daily step count, minutes of moderate to vigorous activity, 2-minute walk test distance, gait speed, balance confidence [S&O]	Examine older, diabetic adults' adherence to recommended physical activity guidelines following discharge from prosthetic rehabilitation.	Physical activity levels for adults with diabetes and lower-limb amputations fall well below recommended guidelines of 6500 steps per day and 150 minutes of moderate to vigorous physical activity per week.
Brunelli (2015), Italy [28]	RCT (n=40)	High	Phantom limb pain, phantom limb sensation [S]	Examine the reduction in phantom pain and sensation with combined training	The combined training program was beneficial in reducing phantom limb

				of progressive muscle relaxation, mental imagery, and phantom exercises.	pain and sensation, and should be considered as a valuable tool to aid rehabilitation.
Wezenberg (2012), The Netherlands [242]	Cross-sectional (n=36), older adults, mostly male	Mod	Peak aerobic capacity, amputation cause and level [O]	Examine associations of aerobic capacity of older adults who underwent a lower limb with the presence, cause (traumatic or vascular), and level of amputation (transtibial or transfemoral).	Vascular amputation group walked at a substantially higher (45.2%) relative aerobic load than the traum amputation group. The preferred walking speed in both groups of amputees was slower than that of able-bodied controls and below their most economical walking speed.
Bragaru (2013), The Netherlands [27]	Cross-sectional (n=175), athletes, male & female	Mod	Descriptors of sports participation, predictors of participation, qualitative assessment of reasons for participations [S]	Examine sports participation of individuals with upper limb deficiency and associated factors.	Over half of participants with upper limb deficiencys participated in sports for at least 60 min/week. Presence of an additional medical problem, level of upper limb deficiency, educational level and participation in sports before amputation were associated with participation in sports. Not participating in sports before

					amputation and lack of motivation were the most common factors associated with not participating in sports.
Deans (2008), UK [60]	Cross-sectional (n=22), male & female	Mod	Activity restriction with athletic, functional, and social subscales (via Trinity Amputation and Prosthetic Experience Scales); physical, psychological, social, and environmental domains of perception of quality of life (via World Health Organization Quality-of-Life Scale) [S]	Examine the relationship between physical activity and perceived quality of life in a lower-limb amputee population, and which aspects of physical activity were most strongly linked to quality-of-life factors.	There was a very strong correlation between scores on the social elements of each questionnaire. Many respondents commendted that the athletic items of the questionnaire (i.e. being able to carry out vigorous activities like running, lifting heavy objects, or participating in strenuous sports) were completely irrelevant to the functional aspects of their lifestyle.
Darter (2013), US [51]	Repeated measures (n=8), male & female	Mod	Temporal-spatial, physiological, and functional gait performance [O]	Examine the effectiveness of a home-based multiple-speed treadmill training program to improve gait performance in persons with a transfemoral amputation.	Home-based treadmill walking is an effective method to improve gait performance in persons with a transfemoral amputation. Particpants improved temporal-spatial gait symmetry at

					self-selected but not at maximal walking speed. A relative interlimb increase in stance duration for the prosthetic limb and proportionally greater increases in step length for the limb taking shorter steps produced the improved symmetry. Energy expenditure decreased progressively, and self-selected walk speed, maximal walk speed and 2min walk time all increased by 16% to 20%.
Halsne (2013), US [88]	Retrospective (n=17), mostly male	Mod	Daily step count, Medicare Functional Classification Level [O]	Examine activity levels, variations, and patterns in adults with lower limb amputation using 12 months of step activity data	Persons with lower limb amputations are greatly limited in regards to activity (averaged 1,540 steps/day). Marked seasonal and monthly patterns in activity were identified. Warmer seasons and months generally promoted higher activity, but peak temperatures and humidity depressed activity.

Littman (2014), US [129]	Cross-sectional (n=158), older adult veterans, mostly male	Mod	Frequency, intensity, time, and type of physical activity, barriers and facillitators, sedentary time and behaviors [S]	Examine the types of physical activities that older individuals with lower-limb loss perform, correlates of regular physical activity, and barriers and facilitators to physical activity.	Forty-three percent were classified as physically active based on weekly moderate- and vigorous-intensity activity. History of vigorous preamputation PA was positively associated with being active, while low wealth and watching 5 hours/day or more of television/videos were inversely associated. Pain- and resource-related factors were the most common barriers. Family and financial support were the most commonly reported potential facilitators. The most commonly reported physical activities were walking/wheeling (65%), muscle strengthening (42%), exercise prescribed by a physical or occupational therapist (32%), and gardening (31%).

Lin (2014), US [128]	Cross-sectional (n=22), mostly male	Mod	Daily step count, comfortable walking speed, six-minute walk distance and step width variability, step length variability of the prosthetic leg and of the sound leg [S&O]	Examine the relationship between physical activity and common performance measures (six-minute walk test, step length variability, step width variability, and comfortable walking speed) in individuals with unilateral lower-limb amputation.	Physical activity correlates strongly to comfortable walking speed (r = 0.76), six-minute walk distance (r = 0.67), and correlates fairly to step width variability (r = 0.44). Physical activity is inversely related to step length variability of the prosthetic leg (r = 0.46) and of the sound leg (r = 0.47).
Miller (2017), US [151]	Repeated measures (n=16), male & female	Mod	Lower extremity strength and flexibility, balance confidence, gait speed [S&O]	Examine the impact of a supervised community–based exercise program on balance, balance confidence, and gait in individuals with lower limb amputation.	Moderate effect sizes were found for the Figure-of-8 Walk Test, Activity-specific Balance Confidence Scale, and gait velocity at comfortable walking speed. The average increase in gait speed was clinically meaningful at .14 m/s.
Wong (2016), US [249]	Pre-test/post-test (n=5)	Low	Balance confidence, balance, walking speed, fear of falling [S&O]	Examine whether a four-session physical therapy program of manual therapy, exercise, and functional training would be feasible for people with lower-limb amputation, and produce	Berg Balance Scale, timed up and go and 2-minute walk test had large effect size changes. A four-session program of manual therapy, exercise, and functional

				medium to large effect size changes in balance and walking ability and self-reported prosthetic function.	training proved feasible and increased balance and walking ability in people with lower-limb amputation.
Wezenberg (2013), The Netherlands [243]	Cross-sectional (n=36), older adults, male & female	Mod	VO2 peak, oxygen consumption, aerobic load, walking economy, walking speed [O]	Examine the relative aerobic load, walking speed, and walking economy of older adults with a lower limb prosthesis, and to predict the effect of an increased aerobic capcity on their walking ability.	People with a vascular amputation walked at a substantially higher (45.2%) relative aerobic load than people with an amputation because of trauma. The preferred walking speed in both groups of amputees was slower than that of able-bodied controls and below their most economical walking speed. peak aerobic capacity is an important determinant for walking ability.
Mandel (2016), Canada [136]	Cohort (n=22), older adults, mostly male	Mod	Balance confidence, daily step count [S&O]	Examine the relationship between balance confidence and community-based physical activity.	Balance confidence significantly lower in the low activity group. There was a positive correlation between balance confidence score and step total.

Bragaru (2011), The Netherlands [26]	Systematic Review (47 studies), male & female	-	Type and effectiveness of training programmes, facillitators, barriers and benefits of physical activity [S&O]	Examine the literature regarding individuals with limb amputations and sport participation.	Cardiopulomnary function of individuals with limb amputations was better when a simple physical exercise programme was included in rehab. Intensity of exercise should be based on HR during anaerobic threshold and not exceed 80% of HR max. The influence of sports on quality of life should be more thoroughly investigated. Determinants of sports particiaption are controversial. A physical training programme to improve cardiopulmonary function as part of the rehabilitation of individuals with limb amputations should be developed and tested for efficacy
Bussmann (2008), The Netherlands [32]	Cross-sectional comparison (n=18), male	Low	Daily step count, minutes of moderate to vigorous activity, heart rate, % heart rate reserve [O]	Examine activity levels of people with a unilateral traumatic transtibial amputation compared to people without an amputation, and to explore whether	Persons with a unilateral traumatic transtibial amputation are considerably less active than persons without known impairments.

				both groups have a similar heart rate response while walking.	Heart rate response during walking was similar in both groups, and is probably regulated by adapting one's walking speed.
Ülger (2009), Turkey [227]	RCT (n=20), mostly male	Low	Pain intensity scores [S]	Examine the effects of phantom limb exercises on phantom limb pain	Pain intensity decreased in all subjects after 4 weeks of treatment in both groups. Both phantom exercises and general exercises resulted in significant pain relief at the end of the 4 weeks' treatment. Patients who performed the phantom exercises had less pain at 4 weeks than those who performed general exercises.
Wong (2016), US [248]	Systematic Review (8 studies), male & female	-	Gait performance and speed, evidence quality [S&O]	Examine the effects of exercise programs on gait performance and assess the overall quality of the evidence for adults ambulating with leg prostheses.	Supervised walking, specific muscle training, balance training, gait training and functional training were the exercise exposure types observed in these studies. Self-selected gait speed was the only consistent

					measure of gait performance. No concensus was reached for type of exercise to recommend, as a variety of exercise protocols were effective.
CEREBRAL PALSY					
Lawrence (2016), Canada [125]	Systematic Review (6 studies), male & female	-	Gross motor function, gait speed, intervention type, overall functional outcomes [O]	Examine the evidence evaluating the effect of exercise on functional mobility in adults with CP.	Four studies showed no statistical difference and trivial effect sizes between the intervention and the control group. Rhythmic auditory stimulation and interactive serious gaming were found to be statistically significant in benefiting adults with cerebral palsy. Evidence of the effect of exercise on functional mobility for ambulatory adults with CP is lacking.
Morgan (2014), Australia [153]	RCT (n=17), male & female	High	Ambulatory self-confidence (balance confidence), gait speed, 2-minute walk distance, and quality of life [S&O]	Examine the safety, feasibility and potential efficacy of balance training in adults with CP.	An outpatient balance training programme is feasible, safe, and may enhance ambulatory self-confidence (non-significant improvement), falls efficacy, fatigue, and

					aspects of balance in ambulant adults with CP. There were no significant between-group differences in the secondary outcomes of gait speed, 2-minute walk distance, and QoL.
McPhee (2016), Canada [148]	Cross-sectional (n=41), male & female	Mod	BMI, waist circumference, body composition, sedentary time, minutes of moderate to vigorous activity, fatigue levels [S&O]	Explore the experience of fatigue in adults with cerebral palsy (CP) inclusive of all levels of the Gross Motor Function Classification System (GMFCS); and to determine if physical activity level, sedentary time, age, or body composition can predict fatigue in adults with CP.	Fatigue has been observed in adults with CP inclusive of all five levels of the Gross Motor Function Classification System. Both minutes of moderate to vigorous activtiy and BMI were shown to be significant predictors of fatigue scores.
Ryan (2014), Ireland [201]	Cross-sectional (n=41), male & female	Mod	PA duration and intensity, sedentary time, adherence to PA guidelines, body mass index, blood pressure, lipid profiles, plasma glucose, insulin sensitivity [S&O]	Examine levels of sedentary, light, moderate-to-vigorous, and total activity in adults with CP to adults without CP. Examine the association between PA components, sedentary behavior and cardiometabolic risk factors in adults with CP.	Relatively young adults with CP participate in reduced levels of moderate-to-vigorous PA and spend increased time in sedentary behavior, potentially increasing their risk of developing cardiometabolic disease.

Hurkmans (2010), The Netherlands [102]	Cross-sectional (n=8), male & female	Low	Energy expenditure, oxygen consumption [O]	Examine energy expenditure of adults with bilateral spastic CP while playing Wii Sports tennis and boxing.	VO2 during standing was 38% greater compared with sitting. Both Wii Sports tennis and boxing increased the VO2 above sitting VO2 (340% and 393%, respectively) , and above standing VO2 (218% and 256%, respectively). Energy expenditure during Wii boxing (5.0METs) was higher compared with energy expenditure during tennis (4.5METs); however, this difference was not significant.
Maeland (2009), Norway [132]	RCT (n=12), male & female	Mod	Gait function, 6-minute walk test, 10m walk test, stair climbing, timed stands test, isokinetic muscle strength of the quadriceps [O]	Examine the effects of a progressive resistance exercise programme of seated leg press on gait function in adults with spastic diplegic CP who experience reduced walking ability.	There were baseline differences between the groups in all outcome measures. The training group walked faster than the control group and the control group completed the timed stand test in shorter time than the training group. There was no

					significant change or difference in change between the groups in any of the outcome measures from baseline to 8 weeks.
Quesada (2014), Spain [191]	Systematic Review (56 studies), male & female	-	Cardiorespiratory fitness, chronic pain and fatigue, bone density, muscle strength, exercise type, quality of life, activities of daily living [S&O]	Examine how exercise interventions may affect people with CP.	Strength and aerobic training in people with CP provoke important benefits that can lead to improvements in QoL by reducing dependence and muscle deficits, and by improving their cardiorespiratory fitness as well as their ability to perform daily-life activities.
Gaskin (2008), Australia [74]	Cross-sectional (n=51), male & female	Mod	PA level (min/day of: exercise, LTPA, household activity), health-related QoL, psychosocial functioning (mood states, physical self-efficacy, social support) [S]	Examine the relationships between physical activity, health-related QoL, and psychosocial functioning (mood states, physical self-efficacy, social support) in adults with CP.	The data was heavily skewed, with many participants reporting that they performed minimalPA and experienced low levels of physical function, and minimal role limitations. PA levels and physical functioning were correlated. Although low PA was reported, high social functioning and high social

					support were commonly reported. However, PA levels were negatively correlated with social support from friends. Typically weak associations between PA and the subscales of theQoL and psychosocial functioning measures.
Efraimidou (2016), Greece [66]	RCT (n=10), male	Mod	Gait speed, static and dynamic balance, self-esteem, mood, psychological parameters [S&O]	Examine the effect of a music and movement intervention program on gait, balance and psychological parameters of 10 male athletes in throwing events (ball and disc) with Cerebral Palsy (CP).	Improved gait, balance, and psychological parameters (self-esteem, mood) in the intervention group
Slaman (2013), The Netherlands [209]	Cross-sectional (n=36), male & female	Mod	Daily step count, aerobic capacity, oxygen consumption, and physical strain during walking at preferred walking speed, fatigue [S&O]	Examine underlying mechanisms of inactive lifestyles among adults with spastic bilateral CP.	Neither aerobic capacity nor oxygen uptake during walking was related to total daily walking time. Physical strain of walking at preferred walking speed was inversely related to total daily walking time. Reduced mobility when more physical strain experienced

					during walking.
Vogtle (2014), US [241]	Repeated measures/cohort pilot (20), male & female	Low	Pain and fatigue scores, heart rate [S&O]	Examine the effect of exercise on pain and fatigue in adults with CP.	Significant beneficial changes were found in the pain and fatigue scales among the ambulatory participants during the intervention phase. Beneficial changes diminished during the follow-up phase. Non-ambulatory participants had a significantly higher average heart rate across exercise sessions and spent more time in their high heart rate training zone.
Peterson (2013), US [184]	Cross-sectional (n=11), male	Mod	Oxygen consumption, respiratory exchange ratio, pain scores [S&O]	Examine the feasibility and potential benefits of using recumbent cross-training for nonambulatory adults with CP.	Recumbent cross-training elicited cardiovascular responses, however appeared to be painful in some participants.
Hearing Impairment					
Tsimaras (2010), Greece [226]	Controlled longitudinal (n=23), male & female	Mod	Aerobic capacity (heart rate, peak minute ventilation,	Examine the effect of a traditional dance training program on aerobic capacity	Significant improvements in all aspects of aerobic capacity and muscle

			VO2peak, time to exhaustion) muscle strength (peak torque of hamstrings and quadriceps)	and muscle strength of adults with hearing loss.	strength in experimental group, no change in control group
Gispen (2014), US [75]	Cross-sectional (n=709), older adults, male & female	Mod	Daily step count, self reported PA levels [S&O]	Examine whether hearing impairment, highly prevalent in older adults, is associated with activity levels.	Greater or moderare hearing impairment had greater odds of being in a lower category of PA than those with normal hearing. Mild hearing impairment was not associated with level of PA.
Intellectual disability					
Shields (2008), Australia [206]	RCT (n=20), male & female	Mod	Muscle strength (1RM and muscle endurance of chest press and leg press, timed stairs test and grocery shelving task) [O]	Examine whether progressive resistance training improves muscle strength, muscle endurance, and physical function in adults with Down syndrome.	Significant improvement in upper-limb muscle endurance in intervention group compared with the control group, and a trend toward an improvement in upper-limb muscle strength and in upper-limb function. There were no significant differences between the groups for lower-limb muscle performance or physical function measures. Progressive resistance training is a safe

					and feasible fitness option that can improve upper-limb muscle endurance in adults with Down syndrome.
Calders (2011), Belgium [33]	Controlled intervention (n=45), male & female	Mod	Muscle strength (peak power, 1RM of upper limb and lower limb, abdominal muscles, hand grip strength and muscle fatigue resistance and sit-to-stand performance), oxygen consumption, 6-minute walking distance, body composition (body weight, BMI, fat mass, free fat mass, waist circumference) , lipid profine (HDL & LDL cholesterol), blood pressure [O]	Examine the effect of combined aerobic and strength training on metabolic and physical fitness in adults with ID compared to endurance training and no training.	Muscle strength significantly increased in combined exercise training group. After only endurance training, only peak power and muscle fatigue resistance improved. Peak oxygen consumption, 6-minute walking distance increased significantly in combined exercise training group. After only endurance training 6-minute walking distance improved compared to control. After training, there were no significant differences for weight, height, BMI, fat mass, fat free mass and waist within

					or between the three experimental groups. There were no significant effects on HDL or LDL within or between the three experimental groups, however total cholesterol was significantly decreased in the combined exercise training, while in the endurance training and control groups no significant changes were observed. After the training programme systolic blood pressure was significantly decreased in the combined exercise training group as well as in the endurance training group compared to the control group.
Casey (2012), Canada [40]	Cohort (n=8), mostly male	Mod	Body composition (% fat mass, BMI), heart rate [O]	Examine the effects of a thirteen-week aquatic exercise and nutrition intervention on percent body fat in adults with ID of varying fat ranges (15%-39%)	~1% mean decrease in body fat % (non-significant). There was a negligible reduction in median BMI. There was no significant reduction in exercising heart rate from pre-

					test to post-test across all participants.
Temple (2009), Canada/US [223]	Cross-sectional (n=154), male & female	Mod	Daily step count [O]	Examine the minimum number of days of pedometer monitoring needed to estimate average weekly step counts	Three days of pedometer wear is sufficient to predict average weekly steps among ambulatory adults with ID.
Temple (2007) Canada [222]	Descriptive correlational (n=37), male & female	Mod	Steps per day, barriers to PA and sedentary behaviour, PA preferences [S&O]	Examine the relationships between participation in physical activity/sedentary behaviour and factors consistent with behavioural choice theory: enjoyment, preference, and barriers.	Linear regression showed barriers to physical activity and preference for sedentary behaviour were significant predictors of steps per day in those with ID. The factor that stands out from this study for the least active individuals was accessibility of physical activity options. Ensuring that the effort needed to engage in physical activity is manageable and perceived as achievable is important.
Hilgenkamp (2012), The Netherlands [93]	Pilot study (n=36), male & female	Mod	Grip strength, walking speed, chair stand, flexibility [O]	Examine the feasibility and test – retest reliability of seven selected performancerelated tests for measuring components of physical fi tness in	All tests to measure physical fitness in older adults with ID had moderate to excellent feasibility and had sufficient

				older adults with ID.	test – retest reliability. No statistically significant learning effects were found.
Stanish (2007), Canada/US [214]	Cross-sectional (n=18), male & female	Mod	RPE, Children's OMNI walk/run scale ratings, heart rate [S&O]	Examine the usefulness of the Children's OMNI Scale as a subjective measure of intensity for adults with ID.	Although relationship between heart rate/workload and reported percieved exertion was positive, it was highly variable. Some people were not able to accurately provide subjective estimates and reports of exercise intensity.
Carmeli (2007), Israel [35]	Cohort (n=21), female	Low	Antioxidant level (superoxide dismutase, catalase, glutathione peroxidase, vitamin E, and vitamin A) [O]	Examine the differences of plasma total antioxidant status, vitamin and enzyme levels in active and nonactive female adults with ID.	Significantly higher production of reactive oxygen and nitrogen species in inactive group. These results suggest that regular physical activity is associated with preserved antioxidants in adults with ID.
Carmeli (2009), Israel [37]	Cohort (n=22), mostly female	Mod	Plasma volume, creatine kinase, myoglobin, glutamine, uric acid [O]	Examine if four weeks of endurance training in adults with ID leads to changes in selected chemical and haematological parameters.	No significant change in plasma volume. Non-significant increase in creatine kinase and myoglobin. Glutamine levels were significantly

					increased as well as levels of uric acid.
Carmeli (2008), Israel/US [36]	Cohort (n=62), older adults, male & female	Mod	Percieved well-being [S]	Examine the effect of physical training on general well-being and self-image in older people with ID.	Positive relationship between perceived well-being and physical training between the experimental and control group.
van Schijndel-Speet (2017), The Netherlands [239]	RCT (n=131), male	High	Levels of physical activity, motor fitness (walking speed, mobility), cardiorespiratory fitness, muscle strength, morphologic and metabolic fitness (blood pressure, cholesterol level, serum glucose, weight, waist circumference), activities of daily living, cognitive functioning, depressive symptoms [S&O]	Examine the effectiveness of a physical activity programme, including an education programme, developed for older adults withID using behaviour change techniques.	Significant improvement in: muscle strength, physical activity level, systolic and diastolic blood pressure, cholesterol loevels, cognitive functioning. Walking speed, mobility, serum glucose, weight, waist circumference, depression scores did not significantly improve. There was a high drop out rate.

Ogg-Groenendaal (2014), The Netherlands [169]	Systematic review (20 studies), male & female	-	Measures and frequency of "challenging behavior", exercise frequency, intensity, time, type [S&O]	Examine the effect of exercise interventions on challenging behavior for people with ID.	Exercise interventions are associated with a significant decrease in challenging behavior. No significant difference was observed between low or high intensity exercise. Little information available on the optimal duration or frequency of exercise interventions. The exercise interventions were mostly provided once a day or every other day. Some evidence that offering exercise multiple times a day is more effective than offering it once a day or once every few days
van Schijndel-Speet (2014), The Netherlands [238]	Qualitative (n=14), older adults, male & female	Low	Exercise preference, facilitators and barriers to physical activity [S]	Explore preferences of older adults with ID for specific physical activities, and to gain insight into facilitators and barriers to engaging in physical activity.	Older adults with ID may benefit from specific physical activity programs, adapted to their individual needs and limitations. Themes concerning facilitators were enjoyment, support from others, social contact and friendship, reward,

					familiarity, and routine of activities. Themes concerning barriers were health and physiological factors, lack of self-confidence, lack of skills, lack of support, transportation problems, costs, and lack of appropriate physical activity options and materials.
Celebańska (2013), Poland [41]	Longitudinal (n=69), male & female	Low	Daily step count, BMI [O]	Examine the level of PA among adults with ID.	Adults with ID seem to be insufficiently active. Only 16% of participants exceeded the recommended amount of 10,000 steps, and the average for the whole group was 6,656 steps per day. No significant correlation was found between the level of physical activity and the level ofID, gender, age, or BMI.
Spanos (2013), Scotland [213]	Systematic review (22 studies), male & female	-	Weight, body composition, exercise frequency, intensity, time, type [O]	Examine the clinical effectiveness of weight management interventions in adults with ID and obesity using recommendations	Group community sessions for behavioural coaching were effective, however "buddy system" type exercise was not

				from current clinical guidelines for the management of obesity in adults.	seen as effective. Only 3/20 multi-component investigations resulted in significant weightloss (5% or more). Current data indicate weight management interventions in those with ID differ from recommended practice.
Masleša (2012), Slovenia [144]	Cohort (n=23), male & female	Mod	Motor flexibility, agility, power, muscle endurance, speed, martial arts skills [S&O]	Examine the relationship between selected motor abilities and motor skills of martial arts as well as how and to what extent a group of people with intellectual disability who regularly practice Gan (inclusive) judo can achieve progress in their martial arts skills (judo, karate, boxing and fencing) after an eight-week training programme. Additionally, whether there were any changes in selected motor abilities.	Speed and endurance improved following judo intervention. All martial arts skills (kicking, punching, lunges, movement, controlled fall) but one ("combination of a floating- hip throw and a mat hold") significantly improved, and all motor abilities (flexibility, standing agility, power, muscle endurance, speed) but one (laying down agility) significantly improved. Improved QoL.

Moss (2009), South Africa [154]	Cross-sectional (n=100), male & female	Mod	Cardiorespiratory fitness, body composition (weight, % body fat) [O]	Examine the coronary heart disease risk profile of adults with ID and to determine the effect of a PA intervention on the coronary heart disease risk profile.	Significant improvements in cardiorespiratory fitness and % body fat. No significant decrease in body weight.
Martínez-Zaragoza (2016), Spain [143]	Controlled Cohort (n=64), males & females	High	Cardiorespiratory fitness, blood pressure, heart rate, body weight [O]	Examine the effectiveness of a multicomponent programme (physical activty, diet and motivation) for overweight and obesity in adults and ID adults.	Improved cardiorespiratory fitness, diastolic blood pressure and heart rate. Significant reduction in body weight, and maintained in the follow up at 6 mths.
Bergström (2013), Sweden [18]	RCT (n=129), male & female	Mod	Daily step count, BMI, waist circumference, life satisfaction [S&O]	Examine the effectiveness of a bahavioural intervention to improve diet and physical activity, targeting both caregivers and residents, in community residences for people with ID.	Improved daily step count by 1608 steps/day. Non-significant improvement in BMI and waist circumferemce. No effect onlife satisfaction
Hilgenkamp (2012), The Netherlands [94]	Cross-sectional (n=257), older adults, males & females	Mod	Daily step count [O]	Examine PA levels in a representative population-based sample of older adults (aged 50 years) with ID.	Only 16.7% complied with the guideline of 10,000 steps/day, 36.2% took 7500 steps/day or more, and 39% was sedentary.
Oppewal (2014), The Netherlands [170]	Longitudinal (n=724), older adults, male & female	Mod	Mobility (gait speed), PA levels, fracture history, spasticity ofthe legs (as an aspect of	Assess the predictive value of physical fitness components for falls in older adults with borderline to profound ID.	Gait speed was the only physical fitness component that significantly predicted falls, but did not

			cerebral palsy), urinary incontinence, heart condition, epilepsy, visual impairments, polypharmacy, behavioral problems [O]		remain significant after correcting for confounders. Extremely low physical fitness levels of older adults with ID. Falls at baseline predicted falls at follow-up.
Cartwright (2016), UK [38]	Qualitative (n=10), male & female	Mod	Barriers, attitudes and opinions of physical activity [S]	Examine the perspectives of people with ID and their carers, on exercise and activity	Three barriers hindered service users with ID from regular involvement in physical activity: (i) acceptance of an inactive lifestyle by carers; (ii) restrictions on activity due to paid carer preferences and resource limitations; (iii) communication issues between family carers and paid carers. Barriers were based on assumptions made by paid and family carers, so there is potential to increase activity by changing attitudes, improving communication and reconceptualising activity as integral to everyday living, rather than as additional

					exercise requiring special resources.
Jones (2007), UK [112]	Cohort (n=8), male	Mod	Heart rate, systolic and diastolic blood pressure, weight, BMI, seizure activity, activity levels, counts of challenging behaviors,QoL, alertness [S&O]	Examine and evaluate a "needs based" exercise program based on rebound therapy developed for persons with a profound ID.	Participation in the exercise program was associated with decreases of frequency of challenging behaviors and increases in QoL (freedom scores) and alertness.
Melville (2015), UK [149]	RCT (n=102), male & female	High	Percentage time in Moderate-Vigorous PA, daily step count, sedentary time, well-being, BMI [S&O]	Examine the effectiveness of a behaviour change programme to increase walking and reduce sedentary behaviour of adults with ID.	No difference in percentage time in Moderate-Vigorous PA, daily step count, sedentary time, well-being or BMI. Adults with ID found questionnaires difficult to complete.
Finlayson (2011), UK [69]	Cross-sectional (n=62), males & females	Mod	Daily step count [O]	Examine the levels and patterns of activity of adults withID, to inform the design of studies aimed at increasing activity and health in this population.	Forty-one (66%) participants wore the activity monitor at least 5 of 7 days. Of these, only 11 (27%) achieved the recommended 10 000 steps per day, and only six (15%) were achieving the

					recommended 30 min of moderate／vigorous activity at least 5 days per week.
Bodde (2009), US [22]	Systematic Review (7 studies) , males & females	-	Barriers to PA [S]	Examine the social and environmental barriers to physical activity for adults with ID	Primary barriers were transportation issues, financial limitations and lack of awareness of options. Other salient barriers included negative supports from caregivers and authority figures (e.g. teachers, coaches and parents) and lack of clear policies for engaging in regular activity in residential and day service programs.
McDermott (2012), US [147]	RCT (n=441), male & female	Mod	Minutes of moderate to vigorousPA, BMI [O]	Examine the effectiveness of a randomised efficacy trial of a health promotion intervention for adults with ID.	No significant effect of participation in this intervention on change in mean minutes of Moderate to Vigorous PA or mean BMI 12 months after classes ended. Non-significant association with odds of reduction of BMI.
Pastula (2012), US [176]	Cohort (n=14), male & female	Mod	Balance, body weight, blood pressure, hip circumference,	Examine the effect of moderate intensity exercise training with health	At 3-month followup, no intervention was consistently

			exercise barriers [S&O]	education on the cognitive function of young adults with ID.	superior; overall reductions in weight, BP, hip circumference, and exercise barriers were obtained.
Pett (2013), US [185]	Cohort (n=30), male & female	High	Aerobic capacity, cognitive functioning, processing speed [O]	Examine the effectiveness of a 12-week healthy lifestyle intervention on weight loss and other behavior changes in young adults with ID.	A 17.5% increase in aerobic fitness was observed, as well as significant improvement in all 3 tests of cognitive function and the combined measure of processing speed. This suggests that exercise training at 60–70% of HRmax can effectively improve the cognitive function of young adults with IDs.
Peterson (2008), US [183]	Cross-sectional (n=131), males & females	Mod	Daily step count [O]	Examine and monitor steps accrued by a sample of adults withID and to describe PA patterns by monitoring steps taken across weekdays, weekends, and hours of the day.	The participants accrued 6508 ± 3296 steps/day. Controlling for age, participants with mild intellectual disability were more active than participants with moderate intellectual disability. A total of 14.1% accumulated 10,000 steps/day. Participants

					were more active on weekdays than on weekends, and least active during the evening period compared to the morning and afternoon hours.
Dixon-Ibarra (2013), US [63]	Cross-sectional (n=109), younger and older adult groups, males & females	Mod	BMI, physical activity levels (daily step count, moderate to vigorous activiyt time, sedentary time) [S&O]	Examine the physical activity patterns of older adults with ID in comparison with younger adults with ID and older adults without ID.	Older adults with ID are performing less physical activity than comparison groups. A small proportion of older adults with ID (6%) met national physical activity recommendations of 150 min of moderate or 75 min of vigorous physical activity in bouts greater than ten minutes across the week
Barnes (2013), US [16]	Cross-sectional (294), male & female	Mod	Daily step count, BMI, PA levels (self-reported; moderate to vigorous activity, activity type) [S&O]	Examine PA levels in adults with ID and examine the associations between self-reported activity types, objectively-measured PA, and objectively-measured BMI.	79.6% of participants were overweight or obese. Biking and jogging/running was associated with lower BMI. The mean amount of moderate-to-vigorous PA per week was 108.6 minutes. Self reports of playing basketball, softball, and outside chores were associated

					with increased moderate to vigorous PA. 23.7% met recommended PA guidelines. The most common activities reported were walking (53.7%) and inside chores (42.5%). 26% reported no activity.
Shangraw (2017), US [205]	Qualitative (n=7), male & female	-	Physco-social factors, well-being, percieved performance [S]	Examine and relate the Basic Needs Theory to sport settings for people with ID.	Meeting the three psychological components of the Basic Needs Theory (autonomy, competence and relatedness) may increase athletes' perceptions of wellbeing, confidence and performance.
Bodde (2012), US [23]	Cohort (n=42), male & female	Low	McGillivray's Nutrition Activity Knowledge Scale (NAKS), Physical Activity Recommendations Assessment (PARA) [S]	Examine novel methods of health education and promotion to increase physical activity among adults with ID.	Significant improvements in McGillivray's Nutrition Activity Knowledge Scale (NAKS) and the Physical Activity Recommendations Assessment (PARA). The education and training methods used were successful in health education.

Ptomey (2017), US [190]	Cross-sectional (n=149), male & female	High	Daily step count [S&O]	Examine the feasibility of adults with ID to track daily steps and wear an accelerometer.	No participant wore the accelerometer for greater than 4 days, and only 26.8% of participants met the 4-day/10-h minimum criterion. Shortening the minimum required wear time from 4 days/10 h to 3 days/8 h, only 66% of participants met the criterion at baseline and 46.8, 40.7 and 29.7% at 6, 12 and 18 months, respectively. Of the 5905 days that participants recorded a non-missing value, only 40.9% of days were found to be plausible, as 56% of days wererecorded as <1703 (implausibly low) and 3.2% of days as >24 369 (implausibly high).
Bazzano (2009), US [17]	Cohort (n=44), male & female	High	Body weight, BMI, waist circumference, access to care, and self-reported nutrition, physical activity levels, life satisfaction [S&O]	Examine the effectiveness of a community based health promotion intervention for adults with ID.	Sixty-one percent of participants reported increased PA. Mean exercise frequency increased from 3.2 times to 3.9 times per week. Mean exercise

					duration increased from 133 minutes to 206.4 minutes per week. Significant improvements in nutritional habits, self efficacy, life satisfaction were reported.. Two thirds of participants maintained or lost weight, with a mean weight loss of 2.6 pounds. Average BMI decreased. Waist circumference decreased in 74% of participants.
de Winter (2009), The Netherlands [59]	Cross-sectional (n=470), older adults, male & female	Mod	PA levels, cardiovascular disease risk factors (body weight, diabetes, hypertension, cholesterol levels), diet habits, smoking and alcohol abuse prevelence [S&O]	Examine the prevalence and correlates of cardiovascular risk factors in older adults with ID.	68.3% did not exercise. Prevelence of cardiovascular disease risk factors: Abdominal overweight (70.4%), diabetes (8.7%), hypertension (36.8%), and hypercholesterolemia (31.8%) were highly prevalent. 98.9% of the participants had an unhealthy diet. Smoking and alcohol abuse prevelence was low.

Crockett (2014), UK [49]	Cohort (n=27), male & female	Mod	Balance, mobility, frequency of falls [O]	Examine the effectiveness of a physiotherapy-led falls pathway service (FPS) for clients withID to promote exercise and prevent falls.	Improved balance and mobility, decreased falls.
Mahy (2010), Australia [135]	Qualitative (n=6), male & female	Mod	Barriers and facillitators to physical activity [S]	Examine the facilitators and barriers to physical activity for adults with ID.	Main facillitators: (1) support from others; (2) activity was fun or had an interesting purpose; and (3) routine and familiarity. Support people play a key role, both as facilitators and barriers, to the participation by adults with Down syndrome in PA. It was evident that adults with Down syndrome in general did not initiate participation in PA; this decision was often made for them by others including their support people.

Boer (2016), South Africa [24]	RCT (n=42), males & females	Mod	Mobility (6-minute walk test, 8 ft up-and-go), leg strength (sit-to-stand), aerobic capacity (absolute and relative VO2 peak, time to exhaustion), body weight, body weight, body compostion (fat mass % body fat, waist and hip circumference), blood glucose, cholesterol, blood pressure [O]	Examine the effect of continuous aerobic training (CAT) vs. interval training (IT) on selected anthropometrical, health, physical and functional parameters of adults with Down Syndrome.	Improvements in mobility (6MWD, 8 ft up-and-go) and leg strength (sit-to-stand) in CAT group only when compared with the control group. Aerobic capacity (absolute and relative VO2 peak, time to exhaustion) in both the IT and CAT group compared with the control group. A significant improvement for relative VO2 peak was also determined for IT compared with CAT. Body weight decreased significantly more in the IT group compared with no training and CAT. No significance between group changes were observed for fat mass, fat percentage, waist or hip circumference in either of the training groups. No significant changes were noted for fasting blood glucose, total cholesterol, systolic and diastolic blood

					pressure in either of the training groups compared with the control group.
Ordonez (2014), Spain [173]	RCT (n=20), obese, females	Mod	Inflammation (tumor necrosis factor-a, interleukin-6 and fibrinogen, and C-reactive protein), % body fat [O]	Examine the influence of aerobic training on pro-inflammatory cytokines and acute phase proteins in obese women with Down syndrome.	Fat mass % significantly decreased with intervention. Tumour necrosis factor-a, interleukin-6 and fibrinogen, and C-reactive protein were all significatly improved with intervention.
Ordonez (2013), Spain [171]	RCT (n=20), obese, females	Low	Aerobic capacity (VO2 peak), plasma leptin, adiponectin levels, body composition (% body fat, waist to hip ratio) [O]	Examine the influence of aerobic training on plasma adipokines in obese women with Down syndrome.	Increased VO2 peak and reduced plasma leptin levels. Plasma leptin levels were sig reduced in intervention group. Significant correlations between plasma leptin and indices of obesity were found. No significant changes were found in adiponectin levels. % body

					fat and waist to hip ratio were reduced.
Bossink (2017), The Netherlands [25]	RCT (n=37), male & female	Low	Cardiorespiratory fitness (oxygen saturation), physical wellbeing, social wellbeing, body composition, muscle hypertrophy, heart rate, quality of life [O]	Examine the feasibility of conducting an RCT to determine the effectiveness of a twenty-week power-assisted exercise intervention in people with profound intellectual and multiple disabilities and to evaluate the potential beneficial effects of this intervention.	Intervention increased oxygen saturation, cardiovascular fitness, and social wellbeing. No sigificant changes in body composition, muscle tone, heart rate, and quality of life. Negative medium effect for physical wellbeing. The power-assisted exercise intervention and trial design were feasible and acceptable to people with profound intellectual and multiple disabilities living in a residential facility. The participants completed on average 81.5% of the intervention sessions
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Bochkezania (2015), Australia [21]	Systematic review (9 studies), mostly male	-	Aerobic fitness, muscle strength, QoL [S&O]	Examine RCT, controlled trials, uncontrolled clinical trials, case series and cross-over studies involving exercise interventions that included a combination of aerobic and strength components for people with SCI.	Existing literature on the SCI population on the effects of combined aerobic and muscle strength training is scarce and of low quality. Little evidence to support improvements in aerobic fitness, but this systematic review provides initial evidence of significant improvements in muscle strength after combined aerobic and muscle strength training.
Fornusek (2014), Australia [71]	Experimental study (n=8), male	Mod	Oxygen consumption, minute ventilation, heart rate [O]	Examine cardiorespiratory responses during FES cycling andFES isometric exercise.	Intermittent leg isometric exercise and cycling using FES elicited similar cardiorespiratory responses. Intermittent FES isometric exercise may be a viable alternative intervention for increasing whole body metabolic rate during sustained exercise training sessions for individuals with paralyzed muscles.

Panisset (2016), Australia [174]	Systematic review (11 studies)	-	Muscle power, body composition, muscle fibre cross-sectional area, muscle fibre type [O]	Examine the efficacy of exercise initiated early after traumatic SCI.	Some consistent evidence for the positive effects of early exercise on muscle tissue within 3-6 months of SCI. Differences in intervention type and outcome measures make this determination.
Harvey (2010), Australia [90]	RCT (n=20), mostly males	Mod	Muscle strength, muscle endurance, performance, movement satisfaction [S&O]	Examine the effectiveness of FES-evoked muscle contractions on progressive resistance training in those with SCI.	Using FES in progressive resistance training improves strength, although it is undetermined if the improvement was clinically important. No improvements in other outcome measures compared to control group.
Tanhoffer (2014), Australia [219]	Cross-sectional (n=14), males	Low	Minutes of moderate-vigorous exercise, fat free mass, body mass, % body fat, waist circumference, daily energy expenditure, basal metabolic rate, VO2 peak [O]	Examine the long-term effects of exercise on energy expenditure and body composition in individuals with SCI.	Those who undertook long-term exercise had significantly greater energy expenditure and higher basal metabolic rate, as well as lower body mass, % body fat and waist circumference. However, even those undertaking exercise still had a high body fat %, and so more specific

					interventions are needed.
Hamzaid (2012), Australia [89]	Cross-sectional (n=5), males	Mod	Power output, metabolic efficiency, mechanical efficiency, oxygen uptake, carbon dixide production, ventilation, heart rate [O]	Examine the biomechanical and physiological responses during FES-elliptical stepping versus FES-cycling in SCI.	Both exercise modalities could deliver appropriate training stimuli for improving the aerobic fitness and strength of SCI individuals. However FES-elliptical stepping might provide greater exercise dose-potency for leg muscle strengthening due to the higher power outputs observed.
Raymond (2010), Australia [193]	Cross-sectional (n=25), male & female	Mod	Fasting and 2-hr plasma glucose concentrations, physcial activity level, METs [S&O]	Examine the associations of physical activity and neurological lesion level with glucose tolerance in SCI.	Those with normal glucose tolerance participated in more moderate-vigorous PA and undertook more non-exercise-related mobility than those with disordered glycemia. PA level is a determinant of glucose tolerance, independent of the extent of neurological impairment.

de Oliveira (2016), Australia [58]	Quasi-experimental (n=100), male & female	Mod	LTPA, QoL, self-esteem, functional goals [S]	Examine the effects of the Spinal Cord Injury and Physical Activity in the Community (SCIPA Com) intervention on LTPA and associated outcomes among SCI participants.	The SCIPA Com intervention significantly improved LTPA and health outcomes, especially among inactive individuals with SCI. SCIPA Com determined to be an ecologically valid intervention that can be delivered the community with the supervision of exercise professionals.
Glinsky (2008), Australia [76]	RCT (n=31), male & female	Mod	Muscle strength, muscle endurance, performance and satisfaction of activities of daily living [S&O]	Examine the effects of an 8-week progressive resistance exercise program on wrist muscle strength, muscle endurance and perceptions of daily living in people with tetraplegia.	The strength and endurance results were inclusive - improvements were observed but not enough to be deemed clinically significant. Participants did not perceive any improvements in hand function as a result of the intervention.
Lovell (2012), Australia [130]	Cross-sectional (n=20), males	Mod	VO2 peak, mechanical efficiency, peak heart rate, peak power	Examine the cardiorespiratory response and mechanical efficiency of highly trained SCI handcyclists with untrained SCI men.	Highly trained SCI handcyclists have a greater aerobic capacity and mechanical efficiency compared to untrained SCI participants.

Harvey (2009), Australia [91]	Systematic review (31 studies)	-	Lean body mass, VO2 peak, insluin sensitivity, power output, cholesterol levels, peak tension, perceived exertion, heart rate, blood pressure, QoL, stress, satisfaction with physical function, walking speed, pain, RoM, hand function, depression, bone mineral content (and more) [S&O]	ExamineRCTs designed to determine the effectiveness of physical interventions for people with spinal cord injury (SCI).	There is initial evidence supporting the effectiveness of some physical interventions on numerous health outcomes for people with SCI. There remains a need for more high-quality trials.
Chain (2012), Brazil [42]	Cross-sectional (n=25), males	Mod	Bone mineral density, vitamin D status, hours of PA per week [S&O]	Examine the influence of PA on bone mass, bone metabolism, and vitamin D status in those with quadriplegia.	The onset of PA after injury and the number of hours exercising influenced bone density. There is a positive combined effect of exercise and calcium intake on both health.
Matos-Souza (2015), Brazil [145]	Observational (n=17), males	Low	Heart rate, carotid intimamedia thickness and diameter [O]	Examine whether regular performance of adapted sports is associated with long-term changes in carotid atherosclerosis of SCI participants.	Regular upper-body sports activities are associated with long-term reductions in carotid atherosclerosis. Adapted sports may be a potential prevention strategy to reduce cardiovascular

					risk.
Gorla (2016), Brazil [81]	Longitudinal (n=13), males	Low	Bone mineral content, fat-free mass, body composition [O]	Examine the longitudinal effects of wheelchair rugby training on body composition of participants with tetraplegia.	Regular training increased lean mass, decreased total body fat mass, and increased bone mineral content in the arms, but decreased bone mineral content in the trunk. Suggest that regular wheelchair rugby training improves body composition in tetraplegia.
Kouda (2012), Japan [120]	Cross-sectional (n=16), male	Low	Plasma interleukin-6, adrenaline [O]	Investigate the cytokine response to exercise in persons with chronic cervical SCI.	At rest, the plasma adrenaline concentration was significantly lower in SCI group than in ablebodied group. Concentration of IL-6 was significantly higher at rest in individuals with SCI. In ablebodied subjects, the plasma adrenaline concentration increased significantly immediately after the exercise and returned to the

					baseline level at 1 h after exercise, and the plasma IL-6 level increased significantly at 1 h after exercise and returned to the baseline level at 2 h after exercise. Adrenaline and IL-6 levels were steady throughout the study in individuals with SCI.
Pelletier (2015), Canada [181]	RCT (n=23), male & female	Mod	VO2 peak, RPE, heart rate, ventilation, peak power output, 1RM [O]	Examine the effectiveness of the PA guidelines for adults with SCI to improve aspects of physical fitness.	The PA guidelines were sufficient to improve aerobic capacity and muscular strength, and should be promoted as a means to improve physical capacity.
Hetz (2009), Canada [92]	Cross-sectional (n=48), male & female	Mod	Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI) (LTPA and activities of daily living), VO2 max, peak power output [S&O]	Examine patterns of participation in activities of daily living and associated fitness-related factors among individuals with SCI.	Sex, spinal cord injury, fitness level and time spent performing LTPA were associated with engagement in certain activities of daily living. Identifying common activities performed by individuals with SCI can provide direction for development of strategies to optimize

					participation.
Pelletier (2013), Canada [178]	Cross-sectional (n=41), male & female	Low	Peak power output, oxygen consumption, heart rate, blood pressure, orthostatic tolerance, self-efficacy [S&O]	Examine physical capacity, autonomic function, and perceptions of exercise among adults with SCI.	Responses to exercise differ depending on lesion level and severity of injury, but overall exercise is well tolerated in those with SCI. Exercise interventions should focus on improving task-specific self-efficacy.
van der Scheer (2017), Canada [233]	Systematic review (211 studies)	-	Cardiorespiratory fitness, power output, muscle strength, body composition, cardiovascular risk factors, bone health outcomes [S&O]	Examine the effects of exercise interventions on fitness, cardiometabolic health, and bone health among adults with SCI.	For chronic SCI, there is low to moderate confidence that 2–3 sessions/week of upper body aerobic exercise at moderate-to-vigorous intensity for 20–40 minutes, plus upper body strength exercise (3 sets of 10 reps at 50%–80% 1RM), can improve cardiorespiratory fitness, power output, and muscle strength. Additionally, there is low to moderate confidence that 3–5 sessions per week of aerobic

					exercise at moderate -to-vigorous intensity for 20–44 minutes can improve cardiorespiratory fitness, muscle strength, body composition, and cardiovascular risk. For acute SCI there is low confidence for all health outcomes.
Zbogar (2017), Canada [253]	Observational (n=87), male & female	Mod	Heart rate, self-report physical activity, wrist accelerometry [S&O]	Examine cardiovascular stress, self-reported physical activity, and physical activity by individuals with SCI during physical therapy and occupational therapy.	The cardiovascular stress experienced during physical and occupational therapy was insufficient to obtain a cardiovascular training effect, and as such represents a lost opportunity to maximise rehabilitation. Additionally, Self-reported minutes of higher-intensity physical activity do not reflect actual time spent at a higher intensity measured objectively via a heart rate monitor.

Pelletier (2014), Canada [179]	Follow-up study (n=17), male & female	Mod	Exercise adherence rates, barriers to participation, exercise beliefs [S&O]	Examine the efficacy of referral from a health-care provider to regular exercise combined with 16 weeks of counselling support following discharge from inpatient or outpatient SCI rehabilitation.	Direct referral and ongoing counselling support following discharge from SCI rehabilitation appears to encourage sustained participation. Specific information on how to adapt and complete aerobic and resistance exercises should also be provided.
Allison (2016), Canada [8]	Longitudinal (n=10), mostly males	Mod	Distance, average speed, aortic and femoral cross-sectional area, stroke volume, cardiac output, immunological markers [O]	Examine the effects of FES training on physiological indices of cardiovascular function as well as molecular indices of inflammation and cardiovascular health in those with SCI.	FES exercise training was sufficient to enhance exercise performance (time and distance to fatigue) and peripheral cardiovascular function, however no changes in any molecular indices of cardiovascular risk were achieved.
Wong (2013), Canada [250]	Cross-sectional (n=36), male & female	Low	Large and small artery compliance, physical activity [S&O]	Examine arterial compliance in endurance-trained SCI individuals, untrained SCI individuals and able-bodied individuals.	Small artery compliance is elevated in endurance-trained individuals with SCI and able-bodied individuals in comparison to

					untrained persons with SCI. Small arterial compliance was markedly below normal levels in inactive persons with SCI. Endurance training may normalise and enhance vascular function in those with SCI.
Zehr (2011), Canada [254]	Systematic review (n=3)	-	Adverse events, dropout [S&O]	Examine the literature for reports of adverse events during exercise after stroke or SCI, and to provide recommendations regarding exercise participation in supervised and unsupervised environments.	At present, due to excessive exclusion criteria or inadequate reporting, it is difficult to determine actual risk of adverse events during exercise for those with SCI. However, it is established that the risk-to-benefit ratio favors the recommendation of exercise.
Pelletier (2014), Canada [180]	Cross-sectional (n=36), male & female	Mod	Peak power output, VO2 peak, heart rate, equipment preference (perceived safety, perceived enjoyment) [S&O]	Examine exercise equipment preferences and compare cardiometabolic demand for passive hybrid and arm-only exercise among adults with paraplegia or tetraplegia.	Arm-only exercises were perceived as safer than hybrid exercise modes for those with SCI. No differences in physiological responses across exercise modalities.

Totosy de Zepetnek (2015), Canada [225]	RCT (n=23), mostly males	Low	Arterial stiffness, endothlial function, body composition, markers of cardiovascular disease risk [O]	Examine the effects of following the physical activity guidelines on vascular health for adults with SCI.	Sixteen weeks of adherence to the physical activity guidelines is insufficient to improve many markers of cardiovascular disease risk, but may prevent decline in body composition. The guidelines should continue to be promoted as a means to increase physical fitness, but changes may need to be made to improve other health outcomes.
Martin Ginis (2010), Canada [137]	Cross-sectional survey (n=695), male & female	Mod	Mins/day of >moderate intensity LTPA [S]	Examine the number of minutes a day of LTPA performed by people with chronic SCI and the injury-related characteristics associated with LTPA.	Daily LTPA levels are generally low in SCI populations. Women, older adults, power wheelchair users and gait aids are some of the subgroups that face unique barriers to LTPA that may require additional resources to overcome.
Martin Ginis (2010), Canada [138]	Cross-sectional survey (n=347), male & female	Mod	Mins/day of >moderate intensity LTPA, type of LTPA [S]	Examine the types, intensities, and average duration of LTPAs performed by people with chronic SCI.	There is considerable variability in the duration, intensity and type of daily LTPA in active SCI populations. Most participants reported

					undertaking mild or moderate intensity LTPA, with resistance training, aerobic exercise and wheeling being the most common activities.
Zbogar (2016), Canada [252]	Longitudinal observational (n=95), male & female	Mod	Self-reported LTPA, wrist or hip accelerometry [S&O]	Examine physical activity occurring outside of physical therapy and occupational therapy sessions during inpatient SCI rehabilitation, and how this activity changes friom admission to discharge.	There was no change in self-report LTPA, however significant increases in physical activity outside of structured therapy from admission to discharge was observed. While LTPA is low in an SCI rehabilitation population, individuals apepar to have the capacity to increase their activity level over the inpatient stay.
Hubli (2014), Canada [101]	Cross-sectional (n=20), mostly males	Low	Aortic pulse wave velocity, blood pressure, heart rate [O]	Examine the aortic pulse wave velocity in athletes and non-athletes with SCI.	Athletes with SCI had improved arterial stiffness compared to non-athletes, which is in agreement with able-bodied literature. This implies that exercise training may improve arterial health and

					potentially lower cardiovascular disease risk in the SCI population.
Arbour-Nicitopoulos (2009), Canada [9]	RCT (n=44), male & female	High	Coping self-efficacy, LTPA, barriers to self-efficacy [S]	Examine the effects of action and coping planning on LTPA and coping self-efficacy in exercise initiates living with SCI.	Action and coping planning appears to be effective in enhancing LTPA and coping self-efficacy beliefs in SCI populations.
Sayenko (2010), Canada [204]	Longitudinal (n=6), mostly males	Low	Balance performance, postural stability, rate of learning [O]	Examine the learning potential and performance improvements during balance training with visual feedback (VBT), and static and dynamic stability during training irrelevant tasks with VBT in individuals with incomplete SCI.	Postural control can be enhanced in individuals with incomplete SCI using VBT. All participants showed substantial improvements during standing in both game performance and training-irrelevant tasks after VBT.
Hitzig (2013) Canada [95]	RCT (n=34), mostly males	Mod	Balance, strength, standing, endurance, weight, cardiovascular health, life satisfaction, QoL, self-care, independence, mobility, economic self-sufficiency, employment [S]	Examine the effects of an FES-assisted walking intervention on QoL and participation post SCI were compared to a non-FES exercise program.	The FES intervention group had a significant increase in mobility scores compared to control group. Despite no significant between-group differences for other outcomes, both groups reported well-being improvements from trial

					participation.
Stapleton (2014), Canada [215]	Secondary analysis of survey data (n=680), male & female	Low	Subjective norms, attitudes, barrier self-efficacy, perceived controllability, intentions [S]	Examine sex differences in predictors of LTPA among those with SCI, and to identify factors that might explain any sex differences in social cognitions.	Men had greater perceived controllability and barrier self-efficacy than women.
Martin Ginis (2011), Canada [139]	Systematic review (69 studies)	-	Body composition, functional performance, physical capacity, muscle strength [S&O]	Examine evidence to systematically develop evidence-informed PA guidelines to improve physical fitness in people with SCI.	Adults with an SCI can obtain important fitness benefits by engaging in at least 20 min of moderate to vigorous intensity aerobic activity two times per week and strength training exercises two times per week, consisting of three sets of 8–10 repetitions of each exercise for each major muscle group.
Martin Ginis (2012), Canada [140]	Review	-	Chronic disease risk, physical capacity, muscular strength, body composition, functional performance, mental health, community integration, social participation	Examine the evidence that links exercise and sports participation to physical and psychological well-being among people with SCI.	Emerging evidence indicates that exercise and sports can have significant physical and psychosocial health benefits for people with SCI. Although there are many challenges to physical activity

			[S&O]		participation in this population, the potential benefits of enhanced participation can be tremendous. Given that people with SCI consider health care professionals to be an important source of physical activity information, it is urged that clinicians talk with their patients about the importance of being physically active.
Phang (2012), Canada [186]	Cross-sectional (n=54), male & female	Mod	Wheelchair skills, wheelchair-use self-efficacy, LTPA barrier self-efficacy [S&O]	Examine whether self-efficacy can account for the relationship between wheelchair skills and LTPA in people with SCI.	Wheelchair skills play a modest role in LTPA participation. Wheelchair skills may facilitate LTPA if these skills make someone feel greater LTPA barrier self-efficacy.
Jeon (2010), Canada [110]	Longitudinal (n=6) males	Low	Oxygen consumption, plasma leptin, insulin, and glucose levels, insulin sensitivity, body composition [O]	Examine the effects of exercise training with an FES rowing machine on insulin resistance, plasma leptin levels, and body composition in people with SCI.	A 12-week FES rowing training programme can improve aerobic fitness and fasting glucose and leptin levels. However, body composition, fasting insluin levels and sensitivity remained unchanged.

					Demonstrates a safe and beneficial mode of exercise to improve fitness and glucose control.
Tawashy (2009), Canada [220]	Cross-sectional (n=49), male & female	Mod	Activities of daily living, pain, fatigue, body mass index, waist circumference, self-efficacy [S]	Examine the intensity level and nature of physical activity in individuals living with SCI, and to explore the relation between descriptive individiual variables, complications and participation.	Approximately 50% of reported PA among individuals with SCI is due to activities of daily living. Greater PA participation is related to fewer secondary complications.
Ballaz (2007), France [14]	Case series (n=15), male & female	Low	Femoral artery blood flow velocity, peripheral resistance, heart rate [O]	Examine the acute femoral artery hemodynamic response during a passive leg cycle exercise in those with SCI.	Acute passive leg cycle exercise increases vascular blood flow velocity in SCI participants. This exercise could have clinical implications for immobilized persons.
Akbar (2015), Germany [3]	Cross-sectional (n=296), mostly males	Low	BMI, estimated risk, PA [S&O]	Examine whether frequent overhead-sports activity increases the risk for rotator cuff disease in people with SCI who are wheelchair dependent.	Overhead-sports activities have been identified as an additional risk factor for developing rotator cuff disease in SCI patients. A high frequency of PA shows physiological and psychological benefits and improved quality

					of life. The dilemma remains of how to increase physical activity to gain health benefits without further increasing overuse of the upper extremities, particularly the shoulder.
Abel (2008), Germany [1]	Cross-sectional (n=36), males	Low	Energy expenditure, heart rate, lactate concentration, oxygen uptake [O]	Examine the energy expenditure of individuals with SCI in ball games for wheelchair-dependent persons.	The energy expenditure of those participating in wheelchair basketball and wheelchair tennis is sufficient to maintain fitness, and is comparable to the ACSM recommendations for able-bodied persons.
Stoner (2007), Greece [218]	Repeated measures intervention (n=5), males	Low	Flow-mediated dilation, arterial range [O]	Examine the effects of neuromuscular electrical stimulation (NMES)-induced resistance exercise therapy on lower extremity arterial health in individuals with SCI.	NMES-induced resistance therapy is capable of improving flow-mediated dilation and arterial range, with potential implications for improved arterial health and reduced risk of cardiovascular disease.

Maggioni (2012), Italy [133]	Case-control (n=35), males	Mod	End-diastolic volume, ejection fraction, intra-ventricular septum thickeness, posterior wall thickness, heart mass, VO2 peak [O]	Examine heart function and morphology between trained and untrained SCI subjects.	Long-term endurance training causes the heart to positively adapt in those with SCI. Regular exercise may increase heart size, sepum and wall thickness, which will likely contribute to improved VO2 peak.
Yamanaka (2010), Japan [251]	Cross-sectional (n=14), males	Low	Natural killer cell cytotoxic activity, plasma adrenaline, cortisol [O]	Examine natural killer cell cytotoxic activity during and after exercise in those with SCI.	Immune response was impaired in response to exercise in SCI subjects, when compared to able-bodied subjects. This is most likely due to a dysfunctional sympathetic nervous system.
Nooijen (2017), The Netherlands [167]	RCT (n=39), mostly males	Mod	VO2 max, BMI, blood pressure, fasting lipid profile, social participation, QoL [S&O]	Examine if SCI rehabilitation that is reinforced with a behavioral intervention to promote physical activity leads to a better health, participation and QoL.	A behavioural intervention promoting PA after discharge from patient rehbilitation appears to improve social participation and reduce cardiovascular disease risk.
Nooijen (2012), The Netherlands [162]	Prospective cohort (n=30), mostly males	Mod	VO2 peak, peak power output, PA, muscle strength, lipid profiles [O]	Examine the relationship between PA level, physical fitness and lipid profiles in people with recent SCI.	Everyday PA plays an important role in the health of persons with a recent SCI. Increased PA level was

					associated with an increase in physical fitness and a reduced cardiovascular disease risk.
van den Berg-Emons (2008), The Netherlands [231]	Prospective cohort (n=40), mostly males	Mod	PA duration and intensity [O]	Examine the PA level after SCI, its determinants, and to compare the PA level 1 year after discharge from the rehabilitation center with the level in able-bodied persons.	PA level increased during inpatient rehabilitation, but this increase did not continue after discharge, and the level 1 year after discharge was distinctly lower than the level in able-bodied persons.
Eriks-Hoogland (2016), The Netherlands [68]	Prospective cohort (n=138), male & female	Mod	Peak power output, wheelchair skills test, ability to transfer, physical activity level, mobility range, employment status [S&O]	Examine whether musculoskeletal shoulder pain and limitations in shoulder RoM at discharge are associated with activities and participation restrictions 5 years later in persons with SCI.	Limitations in shoulder RoM, but not shoulder pain, at discharge is negatively associated with limitations in activities and employment status after 5 years.
Neefkes-Zonneveld (2015), The Netherlands [160]	Systematic review (11 studies)	-	Interleukin-6, plasma C-reactive protein, tumour necrosis factor-α [O]	Examine the effect of long-term PA and acute exercise on markers of systemic inflammation in persons with SCI.	PA and exercise may improve systemic markers of low-grade inflammation in those with SCI, particularly interleukin-6 and C-reactive protein.
Nooijen (2016), The Netherlands [165]	RCT (n=39), mostly male	High	Sedentary time, time spent wheeling, mobility [O]	Examine the effects of rehabilitation that is reinforced with the addition of a behavioural	The behavioural intervention significantly increased wheeled physical activity.

				intervention to promote PA compared to rehabilitation alone for people with subacute spinal cord injury	No significant intervention effect was found for sedentary time or mobility.
Hoekstra (2013), The Netherlands [97]	Pre-test/Post-test (n=10)	Mod	Oxygen consumption, heart rate, METs [O]	Examine the effect of robot-assisted gait training on cardiorespiratory fitness in subjects with SCI and to compare this with recommended guidelines.	Robot-assisted gait training produced no changes in peak VO2, but did induce some improvement in cardiorespiratory fitness (lower resting and submaximal heart rate) despite the low exercise intensity of the training programme.
Nash (2007), The Netherlands [159]	Repeated testing (n=7), males	Mod	1RM, VO2 peak, anaerobic power, shoulder pain [S&O]	Examine the effects of circuit resistance exercise training on muscle strength, endurance, anaerobic power, and shoulder pain in men with SCI.	The circuit resistance exercise training was sufficient in improving muscle strength, endurance, and anaerobic power while significantly reducing shoulder pain.
Valent (2009), The Netherlands [230]	Pre-test/Post-test (n=22), mostly males	Mod	Peak power output, VO2 peak, peak muscle strength, forced vital capacity, peak expiratory flow, shoulder pain [S&O]	Examine the effects of a structured hand cycle training program in individuals with chronic tetraplegia.	Those with tetraplegia were able to improve their physical capacity through regular hand cycle interval training, without participant-reported shoulder-arm pain or discomfort.

Bakkum (2015), The Netherlands [13]	RCT (n=20), mostly males	Mod	Peak power output, VO2 peak, submaximal VO2, heart rate, wheelchair skills test, physical activity [S&O]	Examine the effects of a 16-week hybrid cycle versus handcycle exercise program on fitness and physical activity in inactive people with long-term SCI.	Hybrid cycling and handcycling showed similar effects on fitness and physical activity, indicating that there seem to be no additional benefits of the FES-induced leg exercise over handcycle training alone.
Janssen (2008), The Netherlands	Pre-test/post-test (n=12), males	Mod	Power output, stroke volume, oxygen consumption, carbon dioxide production, pulmonary ventilation, heart rate, cardiac ouput, blood lactate concentration [O]	Examine whether a modified electrical stimulation-induced leg cycle ergometer (ES-LCE) exercise improved performance and responses compared with the standard ES-LCE. Secondly, examine the effects of a 6-week ES-LCE training programme.	A training programme with the modified ES-LCE can elicit marked improvements in performance, peak metabolic and cardiorespiratory responses, and muscle strength to a greater extent than during training on the standard ES-LCE.
de Groot (2009), The Netherlands [54]	Cross-sectional (n=139), mostly males	Low	PA, wheelchair skills, mobility range, social behavior, peak oxygen uptake, peak power output and muscular strength [O]	Examine the physical activity scale for individuals with physical disabilities (PASIPD) in people with SCI.	The PASIPD showed weak-to-moderate relationships with activity and fitness parameters. There seems to be a limited association between self-reported activity level and fitness in people with SCI.

Nooijen (2015), The Netherlands [163]	Cross-sectional (n=37), mostly males	Mod	Exercise self-efficacy (ESE), PA, motility, sedentary time, peak power outout, peak oxygen uptake [S&O]	Examine ESE in persons with subacute SCI, assess ESE in subgroups based on demographic and lesion characteristics, and to explore the relation between ESE and physical behavior and physical capacity.	Persons with tetraplegia had lower confidence, indicating that this subgroup can benefit from extra attention in the promotion of physical activity and exercise. In persons with paraplegia, ESE seemed to be lower in persons with less peak power output and less daily PA.
Nooijen (2015), The Netherlands [164]	Pre-test/post-test (n=41), male & female	Low	Feasability, participant satisfaction, peak power output, VO2 peak [S&O]	Examine the feasibility of a handcycle training program during inpatient rehabilitation and the changes in physical capacity in persons with SCI.	Overall, handcycle training during inpatient rehabilitation in persons with SCI was feasible except for the training frequency. The addition of handcycle training may result in larger increases in physical capacity compared with regular rehabilitation only.
Valent (2008), The Netherlands [229]	Longitudinal cohort (n=162), male & female	Mod	Peak oxygen uptake, peak power output, upper extremity muscle strength, pulmonary function [O]	Examine the influence of hand cycling on outcome measures of physical capacity during and after rehabilitation in persons with SCI.	Regular hand cycling (once a week or more) appeared to be beneficial for improving aerobic physical capacity in persons with paraplegia

					during clinical rehabilitation. The same effect was not found for tetraplegia.
de Groot (2013), The Netherlands [55]	Prospective cohort (n=130), male & female	Low	Total cholesterol, high-density lipoprotein, low-density lipoprotein, triglycerides, body mass index, PA, health behaviours [S&O]	Examine the course of coronary heart disease risk factors in the first five years after discharge from inpatient spinal SCI rehabilitation' and the association between lifestyle and coronary heart disease risk factors during that period.	Lipid profiles seem to stabilize in the years after discharge from inpatient SCI rehabilitation, whereas body mass index increased. Lifestyle factors associated with a favorable lipid profile (self-care related to fitness level, active lifestyle and body mass) and BMI (self-care related to smoking) could be identified.
Nooijen (2016), The Netherlands [166]	RCT (n=39), mostly males	Mod	Fatigue, pain, depression, illness cognition, exercise self-efficacy, coping, social support, physical activity [S]	Examine the mediating effects of physical and psychosocial factors on the intervention effect on PA.	Pro-active coping, exercise self-efficacy, pain disability and helplessness were identified as important concepts in what underlies intervetion effectiveness.
van der Scheer (2016), The Netherlands [232]	RCT (n=29), male & female]	High	RPE, power output, isometric push-force, submaximal fitness, peak aerobic work capacity, performance	Examine the effects of low-intensity wheelchair training on wheelchair-specific fitness, wheelchair skill performance and PA levels in	Low-intensity wheelchair training appeared insufficient for substantial effects on wheelchair skill performance and

			time, ability, strain scores, physical activity [S&O]	inactive people with long-term SCI.	fitness.
Bakkum (2014), The Netherlands [12]	Cross-sectional (n=9), males	Mod	Metabolic rate, heart rate, oxygen pulse, ventilation, RPE [S&O]	Examine metabolic rate and cardiorespiratory response during hybrid cycling versus handcycling at equal subjective exercise intensity levels in people with SCI.	A higher metabolic rate and cardiorespiratory response was induced with hybrid cycling compared to handcycling, despite equal RPE levels. Suggests hybrid cycling is more suitable for obtaining health benefits for those with SCI.
van Koppenhagen (2013), The Netherlands [235]	Prospective cohort (n=130), mostly males	Mod	Peak power ouput, PA, METs, musculoskeletal pain, neuropathic pain, functional independence, body mass [S&O]	Examine the patterns of change in wheelchair exercise capacity from SCI rehabilitation to 5 years post discharge, and to examine the determinants of this change.	The majority of patients after SCI showed a positive trend in wheelchair exercise capacity and can be described in distinct patterns that are dependent on personal, lesion and functional characteristics.
de Groot (2014), The Netherlands [56]	Cross-sectional analyses (n=40), mostly males	Low	20.2km time trial duration, heart rate, peak power output, oxygen uptake, waist circumference [O]	Examine the exercise intensity during a mountain time trial in handcycling and to determine predictors of race time.	Faster race times were achieved by those with a lower waist circumference, greater fitness level and ability to perform at higher average

					exercise intensities during the race. Level of SCI was not associated with race time.
Haisma (2007), The Netherlands [87]	Prospective cohort (n=91), male & female	Mod	VO2 peak, peak power output, spasticity, musculoskeletal and neurogenic pain, secondary health complications, bed rest [S&O]	Examine the association between physical fitness and its recovery over time, and complications and duration of phases of SCI rehabilitation.	The VO2 peak was negatively associated with complications after discharge. Limiting complications, spasticity or bed rest may improve fitness. A longer duration of active rehabilitation is not associated with an increase in physical fitness.
de Groot (2008), The Netherlands [53]	Prospective cohort (n=206), male & female	Mod	Lipid profiles, peak power output, VO2 peak, muscle strength,BMI [O]	Examine the longitudinal relationship between physical capacity and lipid profile in persons with SCI during and 1 year after rehabilitation.	Those with a higher physical capacity after had more favourable lipid profiles, thus reducing the risk for coronary heart disease.
van Koppenhagen (2013), The Netherlands [236]	Prospective cohort (n=128), mostly males	Mod	Peak power ouput, VO2 peak [O]	Examine the course and determinants of wheelchair exercise capacity in SCI up to five years after discharge of inpatient rehabilitation, and describing the loss to follow-up.	Those lost to follow-up appeared to be older and included more persons with tetraplegia. Wheelchair exercise capacity of persons with SCI stabilizes between one year

					after discharge up to five years after discharge
de Groot (2016), The Netherlands [57]	Cross-sectional (n=158), male & female	Mod	Peak power putput, VO2 peak [O]	Examine the impact of time since injury and physical activity on fitness of persons with SCI.	In those with paraplegia, fitness was significantly lower when there had been a longer time since injury. Persons with a long time since injury might need more attention to remain fit, as wheelchair-specific fitness seems to diminish over time.
van Koppenhagen (2014), The Netherlands [237]	Prospective cohort (n=130), male & female	Mod	VO2 peak, peak power output, life satisfaction [S&O]	Examine the relationship between wheelchair exercise capacity and life satisfaction in persons with SCI from the start of active inpatient rehabilitation up to 5 years after discharge.	SCI patients with a greater wheelchair exercise capacity were more likely to have a higher life satisfaction.
Jones (2009), New Zealand [113]	Cross-sectional (n=15), males	Low	Biochemical markers of formation, bone alkaline phosphatase and resorption, deoxypyridinoline [O]	Examine bone activity in active and sedentary SCI males.	Sedentary SCI subjects had higher bone marker formation rates than the active SCI subjects, a result which contrasts with studies in able-bodied

					athletes, in whom exercise has had a positive influence on bone density formation. Further investigation is required to establish the effect of physical activity on bone metabolism in SCI.
Tørhaug (2016), Norway [224]	Cross-sectional (n=12), males	Low	Oxygen uptake, pulmonary ventilation, respiratory-exhange-ratio, blood lactate concentration, heart rate, RPE, power output [O]	Examine if values for peak oxygen uptake and work economy at a standardized workload are different when tested by arm crank ergometry and wheelchair ergometry.	For VO2peak testing, the arm crank and wheelchair ergometry appear equivalent, however if work economy is tested they cannot be used interchangeably.
Lannem (2009), Norway [124]	Cross-sectional survery (n=69), male & female	Mod	PA, life satisfaction, perceived fitness, perceived exercise mastery [S]	Examine the role of physical exercise, perceived exercise mastery and fitness on life satisfaction of individuals with SCI.	Those with SCI who exercised regularly experienced a greater life satisfaction and perceived exercise fitness, but lower perceived exercise mastery than their inactive peers.
Kim (2015), South Korea [119]	RCT (n=15)	Mod	BMI, waist circumference, % body fat, insulin level, homeostasis model assessment of insulin resistance	Examine the effects of a hand-bike exercise program on health parameters and physical fitness in people with SCI.	Exercise using an indoor hand-bike appears to be an effective modality to improve body composition, fasting insulin, and insulin

			levels, VO2 peak, shoulder and elbow RoM [O]		sensitivity and fitness in people with an SCI.
Ordonez (2013), Spain [172]	RCT (n=17), males	Low	Antioxidant status, lipid and protein oxidation, body compostion, physical fitness [O]	Examine the effect of an arm-cranking exercise program on reducing oxidative damage in untrained adults with chronic SCI.	An arm-cranking exercise programme was sufficient to improve the antioxidant defense system in adults with chronic SCI, which may attenuate both lipid and protein oxidation in this population.
Rosety-Rodriguez (2014), Spain [200]	RCT (n=17), males	Low	Plasma levels of leptin, adiponectin, plasminogen activator inhibitor-1, tumor necrosis factor-alpha, and interleukin-6, maximum oxygen consumption, body composition [O]	Examine the effect of arm cranking exercise on improving plasma levels of inflammatory cytokines and adipokines in untrained adults with SCI.	Arm cranking exercise improved low-grade systemic inflammation by decreasing plasma levels of inflammatory cytokines, and plasma leptin levels.
Norrbrink (2012), Sweden [168]	Longitudinal (n=8), mostly males	Mod	Pain, QoL, upper-body strength, aerobic power, mechanical power, cardiovascular risk factors [S&O]	Examine pain relieving effects of an intensive exercise programme on a seated double-poling ergometer in individuals with SCI.	An intensive exercise programme showed promising effects and safety, and can be tried for treating musculoskeletal and neuropathic pain following SCI.

Jörgensen (2017), Sweden [116]	Cross-sectional (n=199), aged >50yrs, male & female	Low	LTPA (amount, intensity and type), sociodemographics, secondary health outcomes [S]	Examine participation in LTPA among older adults with SCI, and to investigate the associations with sociodemographics, injury characteristics and secondary health conditions.	29% reported no LTPA, whereas 53% performed moderate-to-heavy intensity LTPA. The most frequently performed activities were walking and wheeling. Women, wheelchair users and employed participants performed significantly less moderate-to-heavy LTPA. Many older adults with long-term SCI do not reach the amount or intensity of LTPA needed to achieve fitness benefits.
Bjerkefors (2012), Sweden [20]	Cross-sectional (n=26), male & female	Mod	Power output, pole forces, upper trunk RoM [O]	Examine biomechanics during seated double-poling exercises in individuals with SCI and to compare these with those of able-bodied persons.	Upper body kinematics, power and force outputs increased with intensity in both groups, but were in general, lower in SCI. In conclusion, the seated double-poling exercises can be successfully used at low to high work intensities enabling both endurance and strength training for individuals with SCI.

Flank (2014), Sweden [70]	Descriptive, cross-sectional (n=134), mostly males	Mod	Blood pressure, blood glucose, blood lipid profile, PA, BMI [S&O]	Examine whether self-reported PA of a moderate-vigorous intensity influences risk markers for cardiovascular disease in persons with SCI.	Self-reported PA of more than 30 min/day in persons with SCI positively influenced diastolic blood pressure. No other reductions in cardiovascular disease risk markers were seen after controlling for age. Indicates health benefits with PA but it cannot be concluded that PA recommendations in cardiovascular disease prevention for the general population apply to wheelchair-dependent persons with SCI.
Bjerkefors (2007), Canada [19]	Cohort (n=10), mostly males	Mod	Trunk angular and linear displacement, postural stability [O]	Examine whether postural stability in persons with SCI could be affected by training on a kayak ergometer.	Kayak erogmeter training was able to improve the ability of persons with long-standing SCI to maintain an upright sitting position with externally generated balance perturbations. This may translate to an increased capacity to master similar

					balance challenges in everyday life.
Rauch (2016), Switzerland [192]	Cross-sectional survery (n=485), mostly males	Mod	PA (duration, type, intensity) [S]	Examine PA levels in persons with SCI and to investigate associated factors.	PA levels of people with SCI in Switzerland are relatively high - 48.9% fulfilled the World Health Organisation recommendations. Women, those aged >71yrs, and people with complete tetraplegia had significantly lower odds of fulfilling the recommendations.
van Duijnhoven (2010), Switzerland [234]	Case control (n=18), males	Mod	Oxidative stress (malondialdehyde), anti-oxidative capacity (superoxide dismutase and and glutathione peroxidase enzyme levels), VO2 max, body mass [O]	Examine baseline levels of oxidative stress and antioxidative capacity between individuals with SCI and able-bodied subjects, and to examine acute and long-term effects of FES-exercise on oxidative stress and antioxidative capacity in SCI.	A higher aerobic fitness is associated with higher levels of oxidative stress demonstrating the importance to maintain or improve a high physical fitness. Antioxidant capacity is not compromised in moderately active individuals with an SCI. FES exercise training does not result in acute or long-term changes in (anti)oxidative

					status.
Zimmerli (2013), Switzerland [255]	Correlational study (n=22), male & female	Mod	Heart rate, EMG activity from both legs at the tibialis anterior, gastrocnemius medialis, rectus femoris, and biceps femoris, lower extremity function, depression, engagement [S&O]	Examine the influence of different design characteristics of virtual reality exercises on engagement during lower extremity motor rehabilitation.	Interactivity was crucial for the engagement of subjects. Exercises should thoroughly be analyzed regarding their effectiveness, while user preferences and expectations should be considered when designing virtual reality exercises for everyday clinical motor rehabilitation.
Hostettler (2012), Switzerland [100]	Cross-sectional (n=18), males	Low	Cardiac output, heart rate, stroke volume, blood pressure [O]	Examine haemodynamic responses at maximal arm-crank and wheelchair exercise in individuals with SCI and pair-matched able-bodied individuals.	For people with SCI, haemodynamic responses to maximal exercise were similar between modalities. A lower cardiac ouput was observed in SCI subjects compared to able-bodied subjects, perhaps reflecting the inability of the circulatory system to increase stroke volume.
Frotzler (2008), Switzerland [73]	Longitudinal cohort (n=11), mostly males	Mod	Bone mineral density, bone cross-sectional area, bone mineral content, cortical	Examine whether FES induced high-volume cycle training can partially reverse the loss of bone substance in the	High-volume FES-induced cycle training is believed to have clinical relevance as it can partially

			thickness, muscle cross-sectional area, fat cross-sectional area [O]	legs after chronic SCI.	reverse bone loss and thus may reduce fracture risk in the femur.
Allgrove (2012), UK [7]	Cross-sectional (n=9), males	Mod	Heart rate, RPE, blood lactate, leukocytes, neutrophils, lymphocytes, natural killer cells, alpha-amylase activity, saliva flow rate, salivary immunoglobulin A, cortisol [S&O]	Examine the effect of a self-paced handcycling time trial on immunoendocrine responses.	A 1 hour, self-paced handcycling time trial had a limited effect on mucosal immunity but elevated levels of circulating leukocytes. These results suggest that handcycling can temporarily enhance certain immune indices in individuals with SCI.
Nightingale (2017), UK [161]	RCT (n=21), male & female	High	Fasting insulin, insulin resistance, plasma glucose, VO2 peak, power output, PA energy expenditure, minutes of PA, body composition, lipid profile [S&O]	Examine the effect of a moderate-intensity upper-body exercise training intervention on biomarkers of cardiometabolic component risks, adipose tissue metabolism, and cardiorespiratory fitness in persons with SCI.	Moderate intensity upper-body exercise improved aspects of metabolic regulation and cardiorespiratory fitness. Data suggests an improved hepatic but not peripheral insulin sensitivity after 6 weeks of exercise training.
Carty (2012), Ireland [39]	Prospective cohort (n=14), mostly males	Low	VO2 peak, heart rate [O]	Examine the efficacy of a novel neuromuscular electrical stimulation system for improving aerobic fitness in individuals with SCI.	A significant increase in VO2 peak and peak heart rate between baseline and follow-up was observed, suggesting that

					neuromuscular electrical stimulation is an effective method of improving aerobic fitness in an SCI population.
Paulson (2014), UK [177]	Repeated measures (n=5), mostly males	Low	Peak power output, VO2 peak, rate of perceived exertion, interleukin-6, -10 and -1ra, cortisol, adrenaline [S&O]	Examine the feasibility of comparing the plasma inflammation-mediating cytokine response to an acute bout of handcycling with and without the addition of FES-evoked lower-limb cycling.	Initial findings suggest paralysed skeletal muscle releases interleukin-6 in response to FES-evoked contractions. Hybrid exercise may provide a greater anti-inflammatory potential in individuals with SCI compared with handcycling alone.
Al-Rahamneh (2011), United Kingdom [4]	Cross-secional (n=25), males	Low	Submaximal oxygen consumption, predicted VO2 peak, RPE, heart rate, power output [S&O]	Examine the accuracy of predicting VO2 peak from a graded exercise test and a ramp exercise test during arm exercise in able-bodied persons and persons with SCI using RPE.	For persons with paraplegia, the graded exercise test provided a more accurate prediction of VO2 peak, while for able-bodied persons the ramp protocol was more accurate. important implications in assessing maximal functional capacity in rehabilitation settings where maximal exercise testing

					is not feasible.
Goosey-Tolfrey (2010), UK [78]	Case-study (n=8), males	Low	VO2 peak, heart rate, RPE, power output [S&O]	Examine the validity of perception-based intensity regulation during handcycling exercise in an SCI population.	RPE is effective in controlling moderate and vigorous intensities throughout a 20-min handcycling exercise session for SCI participants.
Jones (2014), US [115]	Secondary analysis of an RCT (n=38), male & female	Mod	Walking speed, walking endurance, functional ambulation [O]	Examine who is likely to benefit from activity-based therapy, as assessed by secondary analysis of data obtained from a clinical trial.	Activity-based therapy has the potential to promote neurologic recovery and enhance walking ability in individuals with chronic, motor-incomplete SCI. This analysis identified likely responders to the therapy on the basis of injury characteristics.
Jones (2014), US [114]	RCT (n=48), male & female	Mod	Neurologic function, walking speed, walking endurance, community participation, body mass, insulin sensitivity [S&O]	Examine the effects of activity-based therapy on neurologic function, walking ability, functional independence, metabolic health, and community participation.	Activity-based therapy has the potential to promote neurologic recovery and enhance walking ability in individuals with SCI. However, further analysis is needed to

					determine for whom ABT is going to lead to meaningful clinical benefits.
Gorgey (2016), US [79]	Observational cross-sectional (n=10), mostly males	Mod	Ventilation, CO2 production, carbohydrate utilisation, fat utilisation, fat-free mass [O]	Examine the effects of an acute bout of FES-lower extremity cycling on ventilation, carbon dioxide production, ventilation-to-carbon dioxide ratio, and substrate utilisation in people with SCI.	In persons with SCI, an acute bout of FES resulted in a significant drop in the ventilation-to-carbon ratio, accompanied with a reliance on carbohydrate utilisation and a diminished capacity to utilise fat as a substrate.
Taylor (2011), US [221]	Cross-sectional (n=6), males	Low	VO2 peak, ventilation, respiratory exchange ratio, heart rate, and peak oxygen pulse [O]	Examine magnitude and range of increases in peak aerobic capacity with hybrid–FES rowing versus arms-only rowing in persons with SCI.	Peak oxygen consumption was greater during FES rowing than during arms-only rowing, and as such may provide a more robust exercise stimulus for persons with SCI than other options.
Draghici (2017), US [65]	Cross-sectional (n=14), mostly males	Mod	Peak force, kinetics and kinematics, exercise intensity, oxygen consumption [O]	Examine the biomechanics of FES-rowing to determine how motions, forces, and aerobic demand change with increasing intensity in SCI and able-bodied cohorts.	Despite its ability to allow for whole body exercise, the total force output achievable with FES-rowing results in only modest loading of the legs, and so affects overall rowing performance and may limit forces applied to bone.

Saunders (2012), US [203]	Cross-sectional (n=2245), mostly males	Mod	Behaviour, fatigue, injury severity [S]	Examine behavioral risk factors in relation to fatigue after SCI.	Several behavioral predictors of disabling fatigue were identified, including cardiovascular risk factors, prescription medication use, and alcohol use. These factors are important because they are able to be modified and could be potential factors for prevention or intervention.
Crane (2017), US [47]	Pre-test/post-test (n=89), male & female	Low	Exercise frequency and intensity, perceived health, pain, mood, sleep, television watching habits [S&O]	Examine the initial benefits of a structured group exercise program on exercise frequency and intensity, perceived health, pain, mood, and television watching habits.	There was a significant improvement in days of strenuous and moderate exercise as well as health state. There was an average decrease in pain scores, depression scores and number of hours spent watching television. Participation in structured, small group exercise as a component of a wellness program after SCI shows promise for improving regular exercise participation.

Maher (2016), US [134]	Parallel reliability study (n=38), mostly males	Low	VO2 peak, peak power output, heart rate, total test time [O]	Examine the effect of stage duration on peak physiological response to arm ergometry incremental exercise testing in individuals with SCI.	Stage duration is of little consequence for measuring peak physiological variable, as they produce comparable values.
Alexeeva (2015), US [5]	RCT (n=35), mostly males	High	Walking speed, balance, muscle strength, fitness, QoL, heart rate, performance [S&O]	Examine two forms of device-specific training to comprehensive physical therapy for improving walking speed in persons with SCI.	Persons with SCI can improve walking ability and psychological well-being following a concentrated period of ambulation therapy, regardless of training method. Withholding any formal input from a physical therapist or gait expert was not reduce improvements.
Carlson (2009), US [34]	Systematic review (22 studies)	-	Insulin sensitivity, fasting and post-load blood glucose and insulin concentrations, serum cholesterol levels, physical activity [S&O]	Examine the effectiveness of exercise to improve carbohydrate and lipid metabolism disorders in adults with chronic SCI.	Evidence is insufficient to determine whether exercise improves carbohydrate and lipid metabolism disorders among adults with SCI.

Cratsenberg (2015), US [48]	Systematic review (7 studies)	-	Shoulder pain [S]	Examine the effectiveness of exercise programs on the reduction of shoulder pain in manual wheelchair users with SCI.	Exercise is a feasible, conservative, therapeutic intervention for the treatment of shoulder pain among wheelchair users. Additional studies are needed to differentiate techniques for the reduction of shoulder pain, and to determine the most effective duration of intervention.
Van Straaten (2014), US [240]	Pre-test/post-test (n=16), mostly males	Low	Shoulder pain, shoulder function, shoulder strength [S&O]	Examine the effectiveness of a high-dose home exercise/telerehabilitation program for manual wheelchair users who have a SCI.	A high-dose strengthening program using telerehabilitation for supervision holds promise for shoulder pain treatment in manual wheelchair users with SCI. Additional work is needed to determine effectiveness compared to other interventions.
DiPiro (2016), US [62]	Pre-test/Post-test (n=10)	High	Aerobic capacity, VO2 peak, daily step counts, walking endurance, walking economy, balance [O]	Examine the effects of a non-task-specific, voluntary, progressive aerobic exercise training intervention on fitness and walking-related	Progressive aerobic exercise training is safe, feasible, and effective for improving aerobic capacity, walking speed, and select walking-related

				outcomes in ambulatory adults with SCI.	outcomes in an exclusively ambulatory SCI sample.
Kressler (2014), US [123]	RCT (n=11), mostly males	Mod	Oxygen consumption, fuel utilisation, energy consumption [O]	To investigate effects of circuit resistance training and timing of protein supplementation on fuel utilisation in persons with SCI.	Maximum fat utilisation during exercise and fat utilisation at matched exercise intensities were not increased in persons with SCI, regardless of protein supplementation , and levels of fat oxidation remained low after training.
Myers (2012), US [158]	Pilot study (n=26), males	Mod	Lipid profiles, fasting glucose, insulin sensitivity, body mass index, vital capacity, expiratory volume, heart rate, RPE, physical activity, dietary intake [S&O]	Examine the effect of a customised risk reduction program on cardiovascular risk in males with SCI.	Modest but significant changes in cardiovascular disease risk can be achieved by a multidisciplinary risk reduction program in persons with SCI.
Leech (2016), US [126]	Pre-test/post-test (n=19), male & female	Mod	RPE, stride length, cadence, ankle, knee and hip RoM [S&O]	Examine the effects of short-term manipulations in locomotor intensity on gait performance in people with SCI, and to evaluate potential detrimental effects	High-intensity locomotor exercise and training does not degrade, but rather improves, locomotor function and quality in individuals with SCI, which

				of high-intensity locomotor training on walking performance.	contrasts with traditional theories of motor dysfunction following neurologic injury.
Martin Ginis (2017), Canada [141]	Mixed methods: pre-test/post-test, semi-structured interviews (n=347), mostly male	Mod	LTPA attitudes, subjective norms, perceived behavioural control, intentions, themes related to LTPA barriers and facilitators [S&O]	Examine psychosocial factors which explain lower levels of LTPA in persons with SCI who are ambulatory relative to those who use manual wheelchairs.	Poorer attitudes toward LTPA may partially explain why ambulatory individuals are less active. The qualitative and quantitative data suggest ambulators are an often-overlooked subgroup in need of targeted resources to enhance their attitudes, wheelchair skill self-efficacy and awareness of LTPA opportunities.
Gollie (2017), US [77]	Pre-test/post-test (n=6), mostly males	Mod	Walking speed, oxygen consumption, carbon dioxide production [O]	Examine the effects of a novel overground locomotor training program on walking performance in people with chronic cervical motor SCI.	The overground locomotor training program used in this pilot study is feasible and improved both overground walking speed and walking economy in a small sample of people with SCI.

Martin Ginis (2017), Canada [142]	Systematic review (22 studies)	-	Barriers and facilitators to new guidelines, muscle strength benefits, cardiometaboli c health benefits [S]	Examine the process and outcomes of using a new evidence base to develop scientific guidelines that specify the type and minimum dose of exercise necessary to improve fitness and cardiometabolic health in adults with SCI.	For cardiorespiratory fitness and muscle strength benefits, adults with a SCI should engage in at least 20 min of moderate to vigorous intensity aerobic exercise 2 times per week AND 3 sets of strength exercises for each major functioning muscle group, at a moderate to vigorous intensity, 2 times per week (strong recommendation). For cardiometabolic health benefits, adults with a SCI are suggested to engage in at least 30 min of moderate to vigorous intensity aerobic exercise 3 times per week (conditional recommendation).
Jacobs (2009), US [106]	Randomised comparison (n=18)	Low	1RM, VO2 peak, anaerobic power output [O]	Examine the effects of endurance training against resistance training in persons with SCI.	Persons with paraplegia can significantly improve their upper extremity work capacity, muscular strength, and power by participating in resistance training.

Middaugh (2013), US [150]	RCT (n=15), mostly males	Mod	Shoulder pain, balance, compliance [S&O]	Examine the effect of EMG biofeedback training, in addition to a standard exercise program, on reducing shoulder pain in manual wheelchair users with SCI.	This study provides preliminary evidence that EMG biofeedback has value when added to an exercise intervention to reduce shoulder pain in manual wheelchair users with SCI. This may be valuable in remediating musculoskeletal pain as a secondary condition in SCI.
Lynch (2015), US [131]	Cross-sectional (n=16), mostly males	Mod	Oxygen consumption, caloric expenditure, heart rate [O]	Examine energy expended during several basic physical tasks specific to individuals with SCI.	Resting VO2 for adults with motor-complete paraplegia is 3.0 mL O2/kg/min, which is lower than standard resting VO2 in able-bodied individuals. Use of the standard METs formula may underestimate the level of intensity an individual with SCI uses to perform physical activities.
Collins (2009), US [44]	Cross-sectional (n=170)	Mod	Energy expenditure, Minute ventilation, tidal volume, respiration frequency, oxygen consumption	Examine the energy expenditure of activities commonly performed by individuals with an SCI and to measure resting	Energy expenditure data on 27 activities were measured, and steady-state values were reported. REE in persons with an SCI is lower than

				energy expenditure and establish the value of 1 MET for individuals with SCI.	that reported for the nondisabled, and in the future, adjustments in calculating MET levels should be made accordingly. Moreover, it is proposed that a more precise value for the MET when applied to people with SCI is 2.7 mL·kg−1·min−1.
Jeffries (2015), US [109]	Cohort (n=16), mostly males	Mod	Oxygen consumption, heart rate [O]	Examine acute metabolic and heart rate responses in individuals with SCI during stepping and standing with body weight support.	Individuals with SCI exhibit cardiovascular responses during body weight–supported exercise. Body weight–supported stepping provides a minimal cardiovascular challenge and an emphasis on low weight support during locomotor training can trigger additional heart rate adaptations.
Astorino (2018), US [11]	Cohort (n=9), mostly male	-	Heart rate, VO2 Peak, power output, exercise preference [S&O]	Examine changes in cardiorespiratory and metabolic variables between two interval training regimes and moderate intensity exercise	Interval training induced the greatest intensity and also was unanimously prefered over moderate intensity constant

				to test high intensity interval training feasibility in persons with SCI.	exercise
Lewis (2007), US [127]	Cohort (n=42), male & female	Mod	Heart rate, oxygen consumption, ratings of percieved exertion [S&O]	Examine the relationship between psychologic cues of somatic stress and physiologic responses to exercise in persons with paraplegia and tetraplegia.	Ratings of percieved exertion may not be an accurate way to prescribe or describe intensity for people with SCI, especially for people who are paraplegic.
Mojtahedi (2008), US [152]	Cross-sectional (n=31), male & female	Low	Body composition (whole body, regional and intermuscular adipose tissue), glucose tolerance, insulin action and lipid profile [O]	Examine the impact of exercise training on the relation between whole body, regional and intermuscular adipose tissue and glucose tolerance, insulin action and lipid profile in people with SCI.	30% higher insulin sensitivity in SCI, no difference between groups in glucose and insulin responses or in lipid measures. Adjusting for intermuscular adipose tissue, fasting insulin and insulin sensitivity were significantly better among SCI athletes compared to sedentary, able-bodied participants. Measures of adiposity did not correlate with glucose response or most lipid measures. insulin sensitivity correlated strongly with absolute and

					relative thigh fat mass.
Williams (2014), UK [244]	Qualitative systematic review (18 studies)	-	Themes of barriers and facilitators to LTPA [S]	Examine the barriers, benefits and facilitators of LTPA among people with SCI.	Eight interrelated concepts were identified as barriers, benefits and/or facilitators of LTPA: (i) well-being; (ii) environment; (iii) physical body; (iv) body–self relationship; (v) physically active identity; (vi) knowledge; (vii) restitution narrative; (viii) perceived absences. Based on the synthesised evidence, healthcare professionals need to appreciate the relationships between the barriers, benefits and facilitators of LTPA in order to successfully promote a physically active lifestyle.

Pritchett (2015), US [189]	Cross-sectional (n=15), male	Low	Core temperature, sweat lactate, active sweat gland density, and sweat output per gland, VO2peak [O]	Examined sweat lactate (reflective of sweat gland metabolism), active sweat gland density, and sweat output per gland in 7 SCI athletes and 8 able-bodied controls matched for arm ergometry VO2peak.	Lower Sweat Gland Density (upper scapular) for SCI (22.3 ±14.8 glands·cm-2) vs. AB. (41.0 ± 8.1 glands·cm-2). No significant difference for output per sweat gland between groups. Sweat-Lactate was significantly greater during the second exercise stage for SCI. SCI athletes had less active sweat glands compared to the able-bodied group, but the sweat response was similar (sweat lactate, sweat output per gland) between able-bodied and SCI athletes. This suggests similar interglandular metabolic activity irrespective of overall sweat rate.

Astorino (2009), US [2010]	Cross-sectional (n=9), mostly male	Mod	Oxygen and carbon dioxide uptake, respiratory exchange ratio, heart rate, substrate oxidation [O]	Examine substrate metabolism during combined passive and active exercise in individuals with SCI.	Respiratory exchange rate increased during exercise, reflecting increasing reliance on carbohydrate from 50 to 83% of energy metabolism. Large reliance on carbohydrate utilisation during 30mins of exercise in persons with SCI, with reduced lipid contribution as exercise intensity was increased. Strategies to reduce carbohydrate utilisation and increase lipid oxidation in this population should be addressed, as blunted lypolysis in this population leads to insulin resistance and increased body fat %.
Kressler (2012), US [122]	Cross-sectional (n=12), mostly male	Mod	RPE, respiratory exchange ratio, substrate utilisation [S&O]	Examine substrate partitioning and utilisation patterns associated with ratings of percieved exertion and time trials in SCI populations	RPE but not the talk test appears suitable to predict exercise intensities associated with the highest levels of fat oxidation. However, such intensities are below

					authoritative intensity thresholds for cardiorespiratory fittness promotion, and therefore the applicability of such a prediction for exercise prescriptions is likely limited to individuals with low exercise tolerance.
Mulroy (2011), US [155]	RCT (n=40), male & female	High	Shoulder pain, muscle strength of the shoulder, physical activity level, QoL [S&O]	Examine the effect of an exercise program and instruction to optimize performance of upper-extremity tasks on shoulder pain in people with paraplegia from SCI	Improved shoulder torque strength and quality of life. Shoulder pain decreased to be 1/3 of baseline scores.
Kehn (2009), US [118]	Qualitative (n=15), male & female	Mod	Attitudes regarding physical activity, barriers and facillitators of physical actiivity [S]	Examines the self-reported exercise experiences of people with SCI using a qualitative exploratory design.	Regardless of exercise status, all participants reported physical activity prior to injury and expressed interest in becoming active or maintaining an active lifestyle. Participants identified a range of both motivational and socio-environmental factors that were either facilitating or constraining of such a lifestyle. Non-

					exercisers identified barriers to exercise, including a perceived low return on physical investment, lack of accessible facilities, unaffordable equipment, no personal assistance and fear of injury. Exercisers identified facilitators, including personal motivation, independence, availability of accessible facilities and personal assistants, fear of health complications, and weight management. Exercisers associated a greater range of specific health benefits with being active than non-exercisers.

Mulroy (2015), US [156]	Cohort (n=201), mostly male	High	Muscle strength, physical activity levels, pain [S&O]	Examine predictors of shoulder joint pain in people with paraplegia.	Participants who developed shoulder pain had decreased muscle strength, particularly in the shoulder adductors, and lower levels of physical activity prior to the onset of shoulder pain. Neither factor was a strong predictor of shoulder pain onset. 39.8% developed shoulder pain over the 3-year follow-up period. Baseline maximal isometric torque (normalized by body weight) in all shoulder muscle groups was 10% to 15% lower in participants who developed shoulder pain compared with those who remained pain-free. Lower shoulder adduction torque was a significant predictor of shoulder pain development (although the model used is of limited clinical utility).

Gorman (2016), US [82]	RCT (n=18), male & female	High	Aerobic capactiy (VO2 peak) [O]	Examine the effectiveness of robotically assisted body weight supported treadmill training for improving cardiovascular fitness in chronic motor incomplete SCI.	Exercise group improved peak VO2 by 12.3% during robotic treadmill walking, compared to a non-significant 3.9% within group change observed in controls. Neither group displayed a significant change in peak VO2 during arm cycle ergometry. A repeated measures analysis showed statistically significant differences between treatments for peak VO2 during both robotic treadmill walking and arm cycle ergometry.
Francisco (2017), US [72]	Cohort (n=8), male & female	Mod	Arm and hand function, muscle strength (upper limb motor score, grip, and pinch strength), percieved independence [S&O]	Examine the feasibility, tolerability, and effectiveness of robotic-assisted arm training in incomplete chronic tetraplegia.	Improved arm and hand function tests and strength of upper limb (upper limb motor score, grip, and pinch strength). No improvement in independence measures. Some gains were maintained 6 months post-intervention.

Simmons (2014), US [208]	Systematic review (179 studies), male & female	-	BMI, aerobic capacity (VO2 peak) [O]	Examine and establish reference values of cardiorespiratory fitness applicable to the general, untrained SCI population	Reference cardiorespiratory fitness values based on functional classification as paraplegic or tetraplegic were established (paraplegic: median, 16.0mL/kg/min ; range, 1.4-35.2mL/kg/min; tetraplegic: median, 8.8mL/kg/min ; range, 1.5-21.5mL/kg/min) for untrained men and women. body mass index was associated with 8.7% of the variability in VO2peak.
Myers (2010), US [157]	Cross-sectional (n=89), male & female	Low	Heart rate recovery [O]	Examine the effects of the presence and level of SCI on heart rate recovery (HRR).	Heart rate recovery had a negative relationship with severity of SCI, however was the opposite relationship when normalised for heart rate reserve. Heart rate reserve is strongly associated with peak exercise level and peak heart rate during exercise

Burns (2012), US [31]	Cross-sectional (n=9), male	Mod	Heart rate, VO2 peak [O]	Examine whether exergaming satisfies guideline-based intensity standards for exercise conditioning (40%/50% oxygen uptake reserve or heart rate reserve, or 64%/70% of peak heart rate) in persons with paraplegia.	GameCycle exergaming evoked on average ≥50% VO2 reserve. During XaviX Tennis System exergaming (XTSE) with wrist weights ≥2 lbs, average VO2 reached a plateau of ~40% VO2 reserve. Measurements of heart rate were highly variable and reached average values ≥50% heart rate reserve during GameCycle exergaming at resistance settings ≥0.88 Nm. During Tennis Exergaming average heart rate did not reach threshold levels based on heart rate reserve for any wrist weight.
Rosa (2010), US [198]	Review, male & female	-	Muscle strength, aerobic capacity, balance, mobility, injury risk, exercise frequency, intensity, type, time [O]	Examine and summarise exercise prescriptions for persons with SCI.	Exercises should be heavily varied as to avoid upper extremity overuse syndrome. Stretching these areas is also effective. Focus on muscles in the posterior shoulder and shoulder girdle, especially the

					external shoulder rotators for most transfer to increasing mobility needs of people in wheelchairs. Balance "push" and "pull" muscle work. Trunk stability is also useful.
Stevens (2008), US [216]	Cross-sectional (n=62), male & female	Mod	PA levels, quality of life [S]	Examine the relationship between level of PA and QoL in persons with SCI.	A strong positive association was observed between level of PA and QoL. Multiple regression analysis also showed that when level of physical activity, anatomical location of the injury, completeness of injury, and time since injury were used as explanatory variables, level of PA was the only significant predictor of QoL, accounting for 56% of the total variation in QoL.
Keegan (2014), US [117]	Cross-sectional (n=144), male & female	Mod	Percieved barriers, QoL [S]	Examine the relationship between functional disability and perceived barriers to physical activity and exercise in persons with SCI.	Level of functional disability was a predictor of perceived barriers to PA and exercise. Health barriers were found to be a partial mediator for

					functional disability and physical health-related QoL, suggesting perceived barriers may help to explain the association between functional disability and physical health-related QoL.
Johnston (2016), US [111]	Cohort (n=17), mostly male	Mod	Femur areal bone mineral density, trabecular bone microarchitecture, cortical bone macroarchitecture, bone turnover, muscle hypertrophy [O]	Examine the musculoskeletal effects of low cadence cycling with FES with high cadence FES cycling for people with SCI.	Both groups increased muscle volume (low cadence cycling by 19%, high cadence cycling by 10%). Low cadence cycling showed greater decreases in bone-specific alkaline phosphatase, indicating less bone formation (15.5% decrease for low cadence cycling, 10.7% increase for high cadence cycling). N-telopeptide decreased 34% following low cadence cycling, indicating decreased resorption.

Sadowsky (2013), US [202]	Cohort (n=45), mostly male	Mod	Muscle strength, muscle hypertrophy, % body fat, lipid profiles, triglicerides, bone density [O]	Examine the effect of long-term lower extremity FES cycling on the physical integrity and functional recovery in people with SCI.	FES group had enhanced muscle volume and reduced % body fat. FES enhanced predicted and actual muscle strength measurements while not increasing spasticity. The ratio of total cholesterol to HDL-cholesterol was significantly lower in the FES group as were mean triglyceride and LDL cholesterol levels. Mean HDL-cholesterol was higher in the FES group, but the difference was not statistically significant. Bone density measurements did not reveal any significant differences between the two groups. Importantly, no pathologic fractures occurred in the FES group.
Gorgey (2016), US [80]	Cohort (n=11), male	Mod	Body composition (lean mass, fat mass, % body fat, thigh circumference), metabolic rate and lipid	Examine the effects of cessation of exercise interventions on body composition and metabolic profiles in men	Thigh circumference increased by 8.5% following exercise and remained 6.4% greater than baseline

			profile [O]	with chronic SCI.	measurements. Leg lean mass increased by 9% following the exercise intervention and decreased by 16% in the follow-up visit. whole body lean mass increased by 8.4% and decreased back by 5.4% following a 2.5 year-period. Percentage trunk and total body fat mass increased by 4.5 and 3.5% in the follow-up visit. BMR significantly decreased by 15.5% following the exercise interventions. Positive changes regressed back following 2.5 years of exercise cessation.
Haapala (2008), US [84]	Cross-sectional (n=6), male	Mod	Intensity, cycling time, cadence, joint power output, heart rate [O]	Examine progressive resistance and submaximal cycling protocols to determine which of the two should be considered a more effective paradigm for patients with SCI.	Submax cycling: greater ankle and knee power outputs, lower stimulation levels, cadence longer maintained. This indicates less fatigue than during progressive cycling, and therefore indicates a more effective protocol for SCI riders. A

					hybrid protocol incorporating both strength and endurance training may be even more beneficial.
Wise (2009), US [247]	Cohort (n=21), mostly male	Mod	PA minutes, exercise habits [S]	Examine changes in exercise behavior of individuals with a SCI after interacting with knowledgeable health care professionals and receiving a tailored home program of physical activity.	Both intervention groups increased PA minutes/wk (mean of 36.3 minutes/week to a mean of 127.4 minutes/week). Participant adherence rate was 87.5%. At the conclusion of the study, 70% of the participants in each intervention group had moved to stage of change 5 (maintenance) of the transtheoretical model.The provision of a home exercise program via brochure and DVD/videotape was associated with positive behavior changes related to PA.
Jacobs (2013), US [107]	Cross-sectional (n=10), male	Mod	Energy expenditure, fuel oxidation [O]	Examine and compare substrate oxidation and partitioning during voluntary arm ergometry in individuals with paraplegia and	Maximum fat oxidation was reached at 41 ± 9% VO2 peak for participants with paraplegia. Carbohydrates became the

				non-disabled individuals over a range of exercise intensities.	predominant fuel source during exercise at intensities >30–40% VO2 peak. Both maximal fat oxidation rate and the intensity at which it occurred were significantly lower for the non-disabled subjects than those with paraplegia.
Perrier (2013), Canada [182]	Qualitative (n=14), mostly male	Mod	Narrative analysis [S]	Examine how a unique narrative environment and disability narratives motivated individuals with SCI to engage in LTPA.	Individuals who used a restitution narrative were motivated to engage in functional LTPA because of the desire to maintain the body and restore the past self. The individual who used the chaos narrative preferred solitary LTPA as exposure to others with SCI was a constant reminder of the lost, pre-injury self. Individuals who used a quest narrative explored LTPA options that fit with their interests; these individuals were open to new types of LTPA, such as sport and outdoor

					recreation. The plot of three disability narratives can all motivate the pursuit of LTPA; however, not all types of LTPA are seen as equal.
Smith (2013), UK [210]	Qualitative (n=17), males	High	Narrative analysis [S]	Examines the health narratives told by spinal injured men and the work narratives do on, in, and for them.	This study reveals for the first time the way certain contexts and masculine identities create a new subject of health that cares about doing health work, but not too much. Building on the theoretical knowledge advanced here, this article contributes to practical understandings of men's health and disability by highlighting the potential of narrative for changing human lives and behavior.

Smith (2013), UK [211]	Qualitative (n=500), male & female	High	Ethnographic creative non-fictions [S]	Examine and develop an evidence-based resource for knowing and communicating the complexities involved for both males and females in implementing and sustaining a physically active lifestyle shortly after SCI.	Shows the embodied complexities involved when in rehabilitation for both males and females in implementing and sustaining a physically active lifestyle shortly after SCI. It also makes a contribution to practice by providing researchers, health care professionals, and disability user-groups with a theory and evidence based resource to assist in informing, teaching and enabling people living with SCI to initiate and maintain a physically active lifestyle. Stories may be a highly effective tool to communicate with and to influence spinal cord injured people's activity.
Stevens (2015), US [217]	Cohort (n=11), male & female	Mod	Heart rate, walking speed [O]	Examine heart rate response during underwater treadmill training in adults with SCI.	Walking speed remained the same over the first 3 weeks, and was then systematically increased. Heart rate was reduced by 17% by week 7.

Cowan (2012), US [45]	Cross-sectional (n=12), male & female	Mod	Talk test, RPE, oxygen consumption [S&O]	Examine the exercise intensity of each talk test stage and RPE exercise intensity category and assess whether persons with paraplegia are able to use the talk test to select a “comfortable” exercise workload they could maintain for 15 minutes.	During arm crank exercise when speaking is not comfortable (i.e. a negative talk test), persons with paraplegia are exercising at vigorous intensity, which is sufficient to elicit training effects. During incremental peak exercise testing, RPE does not appear to accurately index low-moderate exercise intensities.
Cowan (2013), US [46]	Cross-sectional (n=180), male & female	Mod	Barriers and facillitators to physical activity [S]	Examine exercise participation barrier prevalence and association with exercise participation status in adults with SCI.	Highly prevalent barriers were not associated with exercise participation status, whereas low prevalence barriers were strongly related to being a non-exerciser. Internal barriers had the strongest association with exercise participation status. The possible association between socioeconomic factors and exercise participation may be underappreciate

					d. The most effective interventions to increase exercise participation may be multifocal approaches to enhance internal perceptions about and motivation to exercise, increase knowledge of how and where to exercise, while also reducing program and transportation financial costs.
Barfield (2010), US [15]	Cross-sectional (n=9), male	Mod	Heart rate [O]	Examine the ability of individuals with a cervical spinal cord injury to achieve and sustain a cardiorespiratory training intensity during wheelchair rugby.	Wheelchair rugby players averaged training intensities from 51-75% heart rate reserve.
Dolbow (2012), US [64]	Cohort (n=17), mostly male	Mod	Exercise adherence [S]	Examine the effects of a home-based functional electrical stimulation cycling program on exercise adherence of those with SCI.	Exercise adherence rates between 63-72%. Age, history of exercise, and pain not associated with the exercise activity were determined to have significant impact on exercise adherence rates. Exercise adherence rates

					were well above the reported 35% in the able-bodied population, which provides evidence for the feasibility of a home-based FES lower extremity cycling program. Younger adults with a history of being physically active have the highest potential for exercise adherence.
Pritchett (2010), US [188]	Cohort (n=7), male & female	Low	Mechanical work, core temperature, skin temperature, thermal sensation, heart rate [O]	Examines the efficacy of spray bottle during rest breaks for athletes with spinal cord injury, who often experience high heat storage due to reduced sweating capacity below the spinal injury. Spray bottle maybe used to apply mist for evaporative cooling during breaks in competitions.	No significant difference between spray bottle group and control in work done, core temperature, skin temperature, thermal sensation, or heart rate.
Valent (2007), The Netherlands [228]	Systematic review (14 studies), male & female	-	Aerobic capacity (VO2 peak), muscle strength (peak power output), evidence quality [O]	Examine the effects of upper body training on the physical capacity of people with SCI	Mean peak power output improvement: 26.1 (15.6)%. Mean VO2peak improvement: 17.6 (11.2)%. Significant improvements recorded in upper body power and in

					aerobic fitness. Low amount of quality evidence
Visual					
Kovács (2012), Hungary [121]	RCT (n=41), older adults, female	Mod	Balance, physcial activty levels, frequency of falls [S&O]	Compare the effects of two exercise programs (strength exercises + walking vs. strength exercises for osteoporosis) on balance and risk of falls in older women with age-related visual dysfunction	Group I (strength exercise + walking) showed a statistically significant improvement in Berg Balance score but not in Barthel Activity Index. Twenty-two (53.7%) of 41 participants fell, 8 of them were in Group I and 14 in Group II. In Group I, the risk for fall reduced by 46% (non-significant). The mean length of time to first fall were 18.5 weeks in the Group I vs. 14.8 weeks in Group II (significant difference)
Cheung (2008), China [43]	RCT (n=50), older adults, female	Low	Balance, timed up-and-go test [O]	Examine the effects of an exercise programme, which focused on improvement of the functional balance of visually impaired elderly.	Improved Berg Balance Scale scores and timed up-and-go test. Contol group did not change.
Haegele (2017), US [86]	Cross-sectional (n=92), males and females	High	PA levels, metabolic equivalent minutes, social support, self-regulation (goal setting, self-	Examine social cognitive theory-based predictors of physical activity and sedentary behavior for adults with visual impairments.	Vision and social spport predicted total metabolic equivalent minutes. Social support significantly predicted self-

			monitoring, problem solving, and scheduling and planning exercise) [S]		regulation & sex (females = more participation). Self-regulation (goal setting, self-monitoring, problem solving, and scheduling and planning exercise) predicted sitting time.
Holbrook (2009), US [98]	Cross-sectional (n=25), male & female	Mod	Daily step count, BMI, % body fat [O]	Examine and document the physical activity levels and body-composition profiles of young and middle-aged adults with visual impairments and addresses the concomitant effects of these factors on perceived QoL	Trend for the interaction between the severity of visual impairment and gender on the percentage of active time spent at high levels of QoL, such that the women who were mildly visually impaired displayed a bias toward a greater percentage of active time spent at high intensities of activity (14.1%) than did the men (5.6%). However, women who were severely visually impaired tended to exhibit a similar percentage of high- intensity active time (4.7%) compared to the men (7.0%), as did women with moderate visual impairments (4.2% and 4.0%,

					respectively). Higher % body fat in women (37% vs 26%), but % body fat not related to step count. Mean daily physical activity level of the participants (8,028 steps) was considerably lower than the activity level of similarly aged healthy adults (11,075 steps per day). QoL not related to PA, however females generally had lower scores than males.
Hackney (2015), US [85]	Cohort (n=32), male	High	Balance, exercise endurance, cognitive dual-tasking, quality of life [S&O]	Examine an adapted tango dance (Tango group) and a balance and mobility program (FallProof group) have improved mobility, balance, and QOL in individuals with visual impairments.	Both groups improved balance, exercise endurance, cognitive dual-tasking, and QoL. Tango group may have experienced greater improvements in exercise endurance, cognitive dual-tasking, and QoL.

Holbrook (2013), US [99]	Cross-sectional (n=31), male & female	Mod	Daily step count [O]	Examine the time frame needed to reliably estimate weekly PA in adults with Visual Impaiment.	Males undertook more steps than females on average. PA levels were similar across a range of visual capabilities, including mild (5,259 ± 3,879), moderate (5,457 ± 4,047), and severe (5,478 ± 3,610) visual impairment. No differences in daily step activity were present across days of the week.
Griffin (2016), Canada [83]	Qualitative/Review (n=30), male & female	-	Themes of aging, physical activity, and visual impairment [S]	Examine the available literature on aging, PA, and sight loss; describe how participation in PA by older adults with visual impairment is understood by researchers; and identify benefits, barriers, and facilitators of PA participation as reported by older adults with age-related sight loss.	Main themes identified that summarize what is known about aging, PA, and visual impairment focus on: (a) participation rates: measuring and recording the rate of PA participation within this population; (b) health inequalities: measuring, recording, and collating the health risks and experiences faced by older adults with sight loss (often linked to activity restrictions); (c) barriers to PA participation; and (d) benefits

					ofPA participation.
Phoenix (2014), UK [187]	Qualitative (n=48), older adults, male & female	High	Themes of facillitators and barriers to physical activity [S]	Examine the ways in which participation in PA is prevented or facilitated among older people with acquired sight loss later in life.	Six themes were identified that captured why PA was prevented or facilitated: disabling environments; organisational opportunities; transport; lack of information; confidence, fear and personal safety; and exercise as medicine.
Ackley-Holbrook (2016), US [2]	Cohort (n=17), male & female	Mod	Daily step count, body compostion (body weight, % body fat, waist circumference), lipid function (total cholesterol, HDLs, LDLs and TGs), heart rate, blood pressure [O]	Examine, develop and implement an adaptive, community-based walking program for adults with visual impairments and to evaluate its impact on daily step activity, cardiovascular health, body composition, and lipid function.	Transition from a "sedentary" activity classification at baseline (4,925 + 2,233 steps per day) to a "somewhat active" profile (8,772 + 2,916 steps per day) following completion of the Walk for Health program. Significant effect on lipid function assessed (total cholesterol, HDLs, LDLs and

					TGs). No significant effects on body compostion, heart rate or blood pressure.
Other					
Jaarsma & Smith (2018), UK [105]	Systematic review	-	Themes related to promoting physical activity for people with impairments who are ready to be active [S]	Examine which psychosocial factors are related to physical activity participation for disabled people who intend to be active, to determine which interventions effectively improved physical activity and to identify how participants were described as intenders.	Twenty studies were included. Self-efficacy, intention and weighing pros and cons were positively associated with physical activity, whereas experiencing barriers and severity of the impairment were negatively associated. Intervention studies reported BCTs such as self-monitoring of behaviour, barrier identification/problem solving and action planning as effective elements of interventions.
Richardson (2016), UK [194]	Qualitative (n=21), male & female	High	Themes related to gym experiences [S]	Examine the feasability of using gym space to promote health in a population of individuals with physical disabilities.	Participants were perceived to experience a variety of health benefits, however they also experienced many barriers such as not

					aligning to the culteral norms of the gym, limited interpretations of health, oppressive messages from the built environment and negative relational interactions.
Hjorth (2014), Denmark [96]	Systematic review	-	Wight reduction mental impairment [O]	Examine controlled intervention studies on reducing overweight/obesity and/or reducing physical illness.	Physical activity interventions reduced weight
Rosenbaum (2014), Australia [199]	Systematic review and meta analysis	-	Findings about aerobic capacity and quality of life [0 & S]	To determine effects of physical activity on depressive symptoms (primary objective), symptoms of schizophrenia, anthropometric measures, aerobic capacity, and quality of life (secondary objectives) in people with mental illness and explore between-study heterogeneity.	Physical activity reduced depressive symptoms in people with mental illness. Physical activity reduced symptoms of schizophrenia and improved anthropometric measures, aerobic capacity, and quality of life among people with mental illness.
Dauwan (2016), Netherlands [52]	Systematic review and meta analysis	-	Outcome measures were clinical symptoms, quality of life, global functioning, depression or cognition. [O]	Investigate the effect of any type of physical exercise interventions in mental impairment.	Physical exercise is a robust add-on treatment for improving clinical symptoms, quality of life, global functioning, and

					depressive symptoms in patients with schizophrenia. The effect on cognition is not demonstrated, but may be present for yoga.
Richardson (2017), UK [196]	Qualitative (n=10), male & female	High	Themes of perceived impact of disabled gym instructors [S]	Examine how disabled gym instructors perceived they impacted the gym environment and the possibilities of making the gym a more inclusive space for disabled people to exercise.	Disabled gym instructors can play a vital role in promoting a more inclusive space to exercise. Additionally, to increase gym use amongst disabled populations, efforts should consider the potential beneficial impacts of disabled gym instructors in relation to promoting health and well-being.
Richardson (2017), UK [195]	Qualitative (n=18), male & female	Mod	Themes related to gym experiences [S]	Examine how exercising as part of a peer group helped disabled individuals make sense of exercising in the gym.	Within their peer group, participants crafted a collective story that they used to resist disablism in the gym. The dialogical components of the collective story functioned to (a) validate participants' experiences of oppression in the gym, (b) forge an

					unspoken understanding with peers, (c) craft a more affirmative identity, and (d) instill a sense of empowerment in participants so that they can tell their own story. Despite the oppression disabled people experienced in the gym, they can create a collective story, which is useful for helping to promote and sustain exercise in this space.
Williams (2017), UK [246]	Qualitative systematic review (10 studies)	-	Themes related to components and outcomes of interventions [S]	Examine participants' experiences and perceptions of physicl activity-enhancing interventions for adults with physical impairments resulting in mobility limitations.	Seven interrelated concepts were constructed representing both components and outcomes of the interventions. These were (i) Diversity of interventions; (ii) Importance of communication; (iii) Need for social support; (iv) Behavioural strategies; (v) Gaining knowledge; (vi) Re-framing thoughts about exercise and the self and (vii) Health and well-being. The results revealed

					that a combination of informational, social and behavioural interventions is perceived as crucial for PA initiation and maintenance.
Papathomas (2015), UK [175]	Qualitative (n=30), mostly male	High	Themes relates to physical activity participation [S]	To identity the types of physical activity narratives drawn upon by active spinal injured people in order to understand why people get active and stay active.	Key narratives that people tell were identified that provide knowledge on behaviour change and motivation to be active and stay active.
Richardson (2017), UK [197]	Qualitative (n=16), mostly male	Low	Themes related to sports participation [S]	Examine the effect of sports participation on psychosocial well-being within disabled populations.	Three broad terms emerged from analysis of the interviews; 1) developed transferrable skills, 2) perceived personal growth and 3) benefits of an athletic identity. Sports participation, in this case wheelchair tennis, may be a viable means to promote psychosocial well-being in disabled populations within developing nations. Sport also holds the potential to challenge negative

					perceptions of disability at an individual and societal level within these cultures.
Williams (2017), UK [245]	Qualitative (n=10), male & female	High	Narrative analysis [S]	Examine how people with SCI experience exercise, and examine how these stories of exercise resonate with, or contest, the "exercise is medicine" discourse.	Three patterns were identified across the whole data-set. These were: (1) exercise and restitution; (2) exercise and pain; and (3) exercise and pleasure. Health professionals, academics and policy-makers need to prescribe to more ethical forms of exercise promotion that may lead to more efficacious, person-sensitive interventions.
Allan (2017), Canada [6]	Qualitative (n=21), male & female	Mod	Narrative type, meaning and value of sport [S]	Examine the meanings that athletes with physical disabilities attribute to their participation in parasport over time.	Five distinct narrative types were identified, which were framed by existing narratives of disability (i.e., restitution, quest) and sport involvement (i.e., performance, discovery, relational). The core of each

					narrative type was formed by the specific meaning or value associated with parasport participation (e.g., sense of purpose, social acceptance). These narratives may be useful for informing strategies and programmes that optimise participation and enhance participation rates.
Shirazipour (2016), Canada [207]	Qualitative (n=18), mostly male	Mod	Percieved expereinces with physical activity [S]	Examine perceptions of a quality physical activity experience for military veterans with a physical disability.	Two overall themes: elements of a quality experience and conditions enabling access to a quality experience. Within the theme of elements of a quality experience, four key themes were identified: group cohesion, challenge, having a role, and independence and choice. Within the theme of conditions enabling access, three themes were identified: physical and social environments, and program

					structure. The study provides a framework for practitioners aiming to foster quality physical activity experiences.
Crytzer (2015), USA [50]	Cross-sectional (n= 24), male & female	Mod	RPE, WHEEL scale, heart rate, power output, VO2 peak [S&O]	Examine the concurrent and construct validity of the Borg Scale and WHEEL Scale during arm ergometry exercise stress testing in adolescents and adults with spina bifida.	The data demonstrated a significant correlation between HR and WHEEL RPE and between VO2 and WHEEL RPE. Future studies that include people with cognitive impairment might consider providing additional time to participants for orientation to the use of the WHEEL RPE Scale. Additional scaling practice may also be warranted, especially if the mode of exercise is new to the individual.
Soe (2012), USA [212]	Survey (n=130), male & female	Mod	Diet, physical activity, sedentary activities, depressive symptoms [S]	Examine age-specific prevalence of selected health risk behaviors in young people with spina bifida and examined the association between health	Compared with national estimates, young people with spina bifida tend to eat less healthy diets, do less exercise, and engage in more sedentary

				risk behaviours and depression.	activities. The findings highlight the need to increase awareness of their health risk profiles in the spina bifida community and show opportunities for mental health and health risk screening and counseling by healthcare providers.
Buffart (2009), The Netherlands [29]	Cross-sectional (n=51), male & female	Mod	physical functioning, social functioning, pain, mental health, vitality, general health perception, physical activity, aerobic fitness, body fat [S&O]	Examine participation and health-related QoL in adolescents and young adults with myelomeningocele and to explore their relationships with lifestyle-related factors.	Of the participants, 63% had difficulties in daily activities and 59% in social roles. Participants perceived lower physical health-related QoL than a Dutch reference population. Participants with higher levels of physical activity and fitness had fewer difficulties in participating in daily activities and a higher physical health-related QoL, but not mental health-related QoL.
Buffart (2008), The Netherlands [30]	Cross-sectional (n=31), male & female	Mod	Lipid profiles, blood pressure, aerobic fitness, body	Examine cardiovascular disease risk factors in adolescents and	A large proportion of the study sample was at risk of cardiovascular

			fat, daily physical activity, smoking behaviour [S&O]	young adults with myelomeningocele and to explore relationships with physical activity, aerobic fitness, and body fat.	disease, indicated by clustering of risk factors. Improving aerobic fitness in young adults with myelomeningocele may contribute in reducing cardiovascular disease risk.

Appendix 6

Examples of reviews compared

Example of impairment specific reviews on the effectiveness of physical activity and exercise to improve disabled adult's health that were compared include:

Author, Year	Impairment Group	Included Studies	Improved Outcome	Evidence Level and Quality	Outcome Confidence
Cardiorespiratory Fitness					
Hicks et al., 2011	SCI	82	Physical capacity	High	High
Tweedy et al., 2017	SCI	-	Cardiorespiratory fitness	High	High
van der Scheer et al., 2017	SCI	211	Cardiorespiratory fitness	Low-Mod	Low-Mod
Valent et al., 2007	SCI	25	Physical capacity, maximal oxygen consumption	Low	-
Martin Ginis et al., 2012	SCI	24	Work rate, maximal oxygen consumption, maximal lactate level, pulmonary function (FES-assisted exercise particularly promising intervention)	-	-
Muscular Strength					
Hicks et al., 2011	SCI	82	Muscle strength	High	High
Bartlo & Klein, 2011	ID	11	Muscle strength	High	High
Tweedy et al., 2017	SCI	-	Muscle strength	High	High
2018 USA Guidelines	-	-	Muscle strength	Mod	Mod
Panisset et al., 2016	SCI	11	Attenuating muscle atrophy	Mod	Mod
van der Scheer et al., 2017	SCI	211	Muscle strength, power output	Low-Mod	Low-Mod
Harvey et al., 2009	SCI	31	Muscle strength	Low-Mod	Low
Bochkezania et al., 2015	SCI	9	Muscle strength	Low	Low

Valent et al., 2007	SCI	25	Power output	Low	-
Martin Ginis et al., 2012	SCI	24	Muscle strength	-	-
Disease Risk and Prevention					
Bragaru et al., 2011	AMP	47	Cardiopulmonary function	High	High
van der Scheer et al., 2017	SCI	211	Cardio-metabolic health; Bone health	Mod-High Low	Mod-High Low
Tweedy et al., 2017	SCI	-	Cardio-metabolic health, respiratory function	Mod	Mod
Nightengale et al., 2017	SCI	-	Cardio-metabolic health	Mod	Low
Carlson et al., 2009	SCI	22	Blood glucose levels, total cholesterol levels, HDL levels, LDL levels, triglycerides	Low-Mod	Low
Panisset et al., 2016	SCI	11	Attenuating bone loss	Low-Mod	Low
Hicks et al., 2011	SCI	82	Body composition	Low	Low
2018 USA Guidelines	-		Reduction in shoulder pain & improves vascular function	Low	-
Martin Ginis et al., 2012	SCI	24	Chronic disease prevention	-	-
Functional Skills					
Bartlo & Klein, 2011	ID	11	Balance; Functional performance	High Mod	High Mod
Lawrence et al., 2016	CP	6	Gross motor function, gait velocity	High	Mod
Tweedy et al., 2017	SCI	-	Functional independence	Mod	Mod
USA 2018 Guidelines	- ID		Upper extremity function; Walking and balance	Mod Low Limited	Mod -
Harvey et al., 2009	SCI	31	Gait improvements	Low-Mod	Low
Hicks et al., 2011	SCI	82	Functional	Low	Low

			performance		
Quesada et al., 2014	CP	56	Activities of daily life	-	-
Martin Ginis et al., 2012	SCI	24	Activities of daily life, functional independence, mobility	-	-
Psychosocial Wellbeing & Community					
Tomasone et al., 2013	SCI	33	Quality of life	High	High
Bartlo & Klein, 2011	ID	11	Quality of life	Mod	Mod
Tweedy et al., 2017	SCI	-	Quality of life, reduced depression risk and shoulder pain	Mod	Mod
Ogg-Groenendaal et al., 2014	ID	20	Reduced challenging behaviour	Low	Mod
Tomasone et al., 2013	SCI	33	Quality of life	High	High
Brooker et al., 2015	ID	6	Wellbeing	Low	Low
USA 2018 Guidelines	-	-	Health related quality of life	Low	-
Quesada et al., 2014	CP	56	Quality of life, independence	-	-
Martin Ginis et al., 2012	SCI	24	Independence, psychosocial wellbeing	-	-

HDL, high-density lipoprotein; LDL, low-density lipoprotein