Adaptive Sports for Disabled Veterans

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PREFACE

The VA Evidence Synthesis Program (ESP) was established in 2007 to provide timely and accurate syntheses of targeted healthcare topics of importance to clinicians, managers, and policymakers as they work to improve the health and healthcare of Veterans. These reports help:

- Develop clinical policies informed by evidence;
- Implement effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures; and
- Set the direction for future research to address gaps in clinical knowledge.

The program is comprised of four ESP Centers across the US and a Coordinating Center located in Portland, Oregon. Center Directors are VA clinicians and recognized leaders in the field of evidence synthesis with close ties to the AHRQ Evidence-based Practice Center Program and Cochrane Collaboration. The Coordinating Center was created to manage program operations, ensure methodological consistency and quality of products, and interface with stakeholders. To ensure responsiveness to the needs of decision-makers, the program is governed by a Steering Committee comprised of health system leadership and researchers. The program solicits nominations for review topics several times a year via the program website.

Comments on this evidence report are welcome and can be sent to Nicole Floyd, Deputy Director, ESP Coordinating Center at Nicole.Floyd@va.gov.

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ACKNOWLEDGMENTS

This topic was developed in response to a nomination by Lucille Beck, PhD and Joel Scholten, MD for the purpose of determining the benefits and harms associations with participation in adaptive sports for Veterans with disabilities as well as to identify facilitators and barriers to participation. The scope was further developed with input from the topic nominators (*ie*, Operational Partners), the ESP Coordinating Center, the review team, and the technical expert panel (TEP).

In designing the study questions and methodology at the outset of this report, the ESP consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicting opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

The authors gratefully acknowledge the following individuals for their contributions to this project:

Operational Partners

Operational partners are system-level stakeholders who have requested the report to inform decision-making. They recommend Technical Expert Panel (TEP) participants; assure VA relevance; help develop and approve final project scope and timeframe for completion; provide feedback on draft report; and provide consultation on strategies for dissemination of the report to field and relevant groups.

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To ensure robust, scientifically relevant work, the TEP guides topic refinement; provides input on key questions and eligibility criteria, advising on substantive issues or possibly overlooked areas of research; assures VA relevance; and provides feedback on work in progress. TEP members are listed below:

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Peer Reviewers

The Coordinating Center sought input from external peer reviewers to review the draft report and provide feedback on the objectives, scope, methods used, perception of bias, and omitted evidence. Peer reviewers must disclose any relevant financial or non-financial conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The Coordinating Center and the ESP Center work to balance, manage, or mitigate any potential nonfinancial conflicts of interest identified.

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INTRODUCTION

The term "adaptive sports" is used to describe a sport that has either been adapted specifically for persons with a disability or created specifically for persons with a disability. For persons with physical disabilities, organized sports can be traced back to the early 1900s. However, opportunities expanded greatly in the post-World War II era, when adaptive sports began to be used for rehabilitation of Veterans. Many of the early programs were in downhill skiing but the range of available sports and opportunities for participation at all levels, from recreational to competitive, has broadened greatly.

Within the Department of Veterans Affairs (VA), the vision of the National Veteran Sports Programs and Special Events (NVSP&SE) office is "to be leaders in the provision of adaptive sports and therapeutic arts programs that complement VA's rehabilitation system of care for Veterans and members of the Armed Forces with disabilities." The national rehabilitation events are intended to "provide opportunities for Veterans to improve their independence, well-being, and quality of life through adaptive sports and therapeutic arts programs."

The purpose of this report is to systematically review the available evidence on the benefits and harms of adaptive sports participation and the barriers to and facilitators of participation. With input from our Operational Partners and Technical Expert Panel members, the scope of the project was limited to the following medical conditions: amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness. Further, the scope was limited to the adaptive sports listed in Executive Summary Table 1.

Executive Summary Table 1. Adaptive Sports Eligible for Inclusion in Evidence Review

Alpine skiing	Golf	Surfing
Archery	Hand-cycling	Swimming
Athletics/ Track & field	Kayaking/Canoeing	Table Tennis
Billiards	Nordic Skiing	Tennis (including Wheelchair Tennis)
Boccia (Bocci, Bocce)	Para-Triathlon	Weightlifting-Power Lifting
Climbing	Sailing	Wheelchair Basketball
Curling	Shooting	Wheelchair Fencing
Cycling	Sitting Volleyball	Wheelchair Lacrosse
Equine Assisted Activities and Therapies (EAAT)	Sled Hockey	Wheelchair Rugby

We addressed the following key questions:

Key Question 1. What is the effectiveness of participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord

injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

Key Question 1a. Does the effectiveness vary by frequency/duration of adaptive sport program participation?

Key Question 1b. Do particular patient groups (*ie*, age range, gender, race, time since injury, time involved in adaptive sports, type and/or severity of disability) benefit more than others from adaptive sports participation?

Key Question 2. What are the potential harms of participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

Key Question 3. What are the known facilitators of and barriers to the participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

METHODS

Data Sources and Searches

We searched MEDLINE, EMBASE, SPORTDiscus, and Rehabilitation and Sports Medicine Source from 1995 to July 2018 using Medical Subject Headings (MeSH) and key words for the adaptive sports and medical conditions of interest.

Study Selection

Citations were entered into Distiller SR (Evidence Partners). Titles were reviewed by a single investigator or research associate. Abstracts of titles identified as potentially eligible were reviewed independently by 2 reviewers with a citation moving to full-text review if either reviewer considered the citation eligible. At the full-text review, agreement of 2 reviewers was needed for study inclusion or exclusion; disputes were resolved by discussion with input from a third reviewer, if needed.

Due to the large number of citations, we also used the DistillerAI (Artificial Intelligence) feature to complete an AI Audit review of titles. References identified by Distiller AI were reviewed at the abstract level by an investigator and proceeded to full-text review as described above.

For Key Question 1 and 2 we included intervention studies comparing participation in an adaptive sports program to usual care, no intervention, or other intervention among individuals with a medical condition of interest. We label these as “sports program studies”. To expand the number of potentially eligible studies and provide possible information for the development of future programs, we also included studies of individuals participating in organized adaptive sports activities although the activity wasn’t specifically implemented for the purpose of

determining whether participation provided benefits or harms. We label these as "sports activity participation studies" – typically cross-sectional observational studies.

For Key Question 3 we included studies assessing facilitators of and barriers to participation in adaptive sports among individuals with a medical condition of interest.

At all levels of review, the inclusion and exclusion criteria were as follows.

Inclusion:

- Age 18 and older with 1 or more medical conditions of interest (ALS, limb amputation, hearing loss or deafness, MS, PTSD, spinal cord disorder, SCI, CVA, TBI, or visual impairment or blindness);
- Participation in 1 or more adaptive sports of interest (Executive Summary Table 1) at the community level or higher (to include adaptive sports programs that begin during inpatient rehabilitation and continue to an outpatient/community-based phase);
- Reporting an outcome of interest; *primary outcomes* of interest were a) clinically important changes in health and wellness, daily functioning, self-esteem, perceived competence, community reintegration, participation in social activities, participation in employment, mood//quality of life, and health care utilization; b) harms related to participation in adaptive sports; and c) barriers and facilitators related to adaptive sports participation; *secondary outcomes* were: a) participation in adaptive sports programs and b) improvement in physical health or PTSD scale scores.

Exclusion:

- Sports programs with modifications of equipment or environment/culture exclusively based on participant age;
- Individual fitness programs or other activities done outside of a program led by a coach or program director (exception – athlete training for competition);
- Study of a sport activity other than pre-defined sports of interest or where >75% of participants are involved in sport not of interest;
- Study of a group of individuals with condition not pre-defined as condition of interest or where >75% do not have a condition of interest;
- Rehabilitation programs with no "sport" component;
- Study of "physical activity" levels where physical activity includes items like household work, gardening, volunteering outside the home (*ie*, studies of physical activity must have included a "sport" component);
- Engineering/modeling studies;
- Human performance laboratory studies.

Data Abstraction and Quality Assessment

We abstracted study design and demographic data from eligible studies including medical condition(s), age, gender, and time since injury/diagnosis; adaptive sport; and US Veteran status. We also abstracted primary and secondary outcomes of interest (see Inclusion, above).

We did not formally assess risk of bias of individual studies due to the many study design variants in the included literature. For each included study, we reviewed critical elements of either observational and experimental studies or qualitative studies based on checklists developed by the Joanna Briggs Institute (http://joannabriggs.org/).

Data Synthesis and Analysis

For Key Question 1, tables were developed by outcome and stratified by whether the study reported on an adaptive sport program ("sports program studies") or provided a cross-sectional view of adaptive sport participants ("sports activity participation studies"). Subgroups of interest included: time since injury or diagnosis, frequency/duration of participation, age, gender, race, and type and/or severity of disability.

For Key Question 2, we also report outcomes from adaptive sports program and sports activity participation studies.

For Key Question 3, the International Classification of Functioning, Disability, and Health (ICF) model was used to summarize motivators to participation in adaptive sports, facilitators of participation, and barriers to participation.

For all Key Questions, findings were narratively synthesized.

We did not formally rate the overall quality of the evidence due to heterogeneity of participants, adaptive sports, study designs, and outcomes assessed.

RESULTS

Results of Literature Search

Searching multiple bibliographic databases (1995 to July 2018) and removing duplicate citations yielded a total of 13,404 citations. Review at the title level excluded nearly 12,000 citations leaving 1,631 for abstract review. Over 1,100 abstracts were excluded resulting in 450 articles for full-text review with an additional 23 from DistillerAI. Following full-text review, there were 118 articles eligible representing 114 studies. Twenty-four of the articles provided data on elite athletes (*eg*, Paralympians or World Championship participants) and were not included in our analyses, as findings would be of limited applicability to the Veteran population.

Summary of Results for Key Questions

Key Question 1

Fifty-five studies reported an objective measure of at least 1 effectiveness outcome of interest. We grouped outcomes into 7 categories: Health and Wellness, Daily Functioning, Self Esteem/Perceived Competence, Mental Health (including mood, depression, and PTSD), Quality of Life, Community Reintegration/Social Participation, and Employment. We also grouped studies into 2 groups: sports program studies and sports activity participation studies. Sports program studies described an adaptive sports program with multiple sessions over a period of a few days or weeks. Outcomes were often assessed both before and after participation in the program. Sports activity participation studies were typically cross-sectional, providing a one-time assessment of participants who engage in adaptive sports.

Sport Program Studies

Evidence of the effectiveness of implementing an adapted sports program is largely from studies of equine assisted activities and therapies (EAAT) and in populations with a history of PTSD, MS, or CVA. There is little information about effectiveness of adaptive sports programs involving other sport activities and other populations.

Outcomes by Sport

Equine Assisted Activities and Therapies (EAAT). Various forms of EAAT for individuals with PTSD were consistently associated with improved mental health outcomes (including overall mental health, depression, PTSD, and anxiety symptoms). Three of the 4 studies of EAAT for individuals with PTSD enrolled exclusively US Veterans. EAAT may be associated with improved balance and reduced fatigue in those with a history of MS. Other outcomes in individuals with PTSD, MS, or history of CVA were infrequently reported.

Hiking/Climbing. Findings from 3 studies of hiking and/or climbing programs for individuals with MS suggest that program participation was not associated with changes in different aspects of health and wellness including balance, fatigue, and cognitive function. Other outcomes were reported by only 1 study.

Golf. Golf programs, evaluated in 3 studies enrolling individuals with a history of CVA, may be associated with improved balance but there was little reporting of other outcomes including measures of cognitive function, daily functioning (walking task), depression symptoms, or impact of health on quality of life.

Fly-fishing. Results from 2 fly-fishing programs for Veterans with PTSD symptoms found program participation was associated with improvement in PTSD symptoms and other mental health outcomes. There was limited reporting of other outcomes.

Ski/Snowboard, Curling, Surfing, Multiple Sport Program. There was limited reporting (2 or fewer studies) of outcomes for these activities with studies including individuals primarily with PTSD or SCI. Available studies suggest that ski/snowboard, surfing, and multiple sports programs may be associated with improved mental health symptoms including PTSD symptoms, depression, and mood.

Outcomes by Population

PTSD. Among 8 studies of individuals with PTSD (7 of which enrolled exclusively Veterans), EAAT, fly-fishing, ski/snowboard, or surfing programs were associated with improved mental health outcomes. Few studies reported other outcomes of interest.

Multiple Sclerosis. In 5 studies of individuals with MS, EAAT programs were generally associated with improved balance. There was little reporting of other outcomes. Similarly, there was little reporting of outcomes associated with hiking/climbing programs (3 studies).

Stroke. For individuals with a history of CVA, results were mixed regarding influence on balance with 1 of 3 studies finding an association between program participation and improved

balance. Both EAAT and golf therapy programs may be associated with improved quality of life but overall few studies reported outcomes of interest.

Spinal Cord Injury. For individuals with SCI, few outcomes were reported to allow assessment of effectiveness of ski/snowboard programs, wheelchair curling, or multi-sport programs (1 study of each sport).

Multiple Conditions. A single study of a multisport program for 18 US Veterans with a variety of post-combat disabilities found that program participation was associated with improved self-esteem, mood, and quality of life.

Sports Activity Participation Studies

Evidence of the effectiveness of adapted sports activity participation is largely from studies assessing participation in sports overall and in populations with SCI. There is little information about effectiveness of participation in specific sports or in other populations.

Outcomes by Sport

Wheelchair Basketball, Wheelchair Rugby, Goal ball, Cycling, Soccer. There was little information on outcomes among participants in these sports. No outcome was reported by more than 1 study.

Multiple Sports. Among studies enrolling participants from a variety of sports, the most commonly studied population was individuals with SCI. Participation in adaptive sports for individuals with SCI was consistently associated with greater self-esteem, athletic identity, and self-efficacy, and higher quality of life. Results were less consistent for mental health, community integration, and employment outcomes. Sports participation was associated with better balance outcomes for individuals with visual impairment. Quality of life was generally higher among sports participants with various medical conditions.

Outcomes by Population

Spinal Cord Injury. Fifteen of 20 studies enrolling individuals with SCI included participants from a variety of sports. Participation in adaptive sports was consistently associated with greater self-esteem and self-efficacy and better quality of life. Results were less consistent for mental health, community integration, and employment outcomes, and there was little reporting for health and wellness or daily functioning. Few outcomes were reported for individuals with SCI participating in wheelchair basketball or wheelchair rugby.

Visual Impairment. Among individuals with visual impairment, 1 study reported that participation in either goalball or soccer was associated with improved balance, while separate studies of these sports found no difference in balance measures between blind goalball players and blind sedentary individuals or blind soccer players and sighted soccer players. There were few reports of other outcomes

Limb Amputation. A single study of 11 soccer players with limb amputations reported a balance score and a quality of life measure but without a comparison (either pre-participation or another group).

Multiple Conditions. Sports participation (representing multiple sports) by individuals with multiple conditions was generally associated with higher quality of life. Other outcomes were reported by a single study.

Key Questions 1a and 1b

Few studies (and no sports program studies) reported on whether effectiveness varied by frequency or duration of adaptive sports participation. More frequent participation was associated with higher athletic identity scores. One study reported that scores on several mental health measures were more favorable in the "high active" group compared to the "low active" or inactive groups.

Similarly, few studies (and no sports program studies) reported on whether effectiveness varied by age, gender, race, time since injury, time involved in adaptive sports or type and/or severity of disability. Three studies of individuals with SCI participating in multiple sports reported higher athletic identity scores for males than females, while a study of wheelchair athletes (multiple sports) found ego and task orientation were similar for male and female participants. One study reported higher self-esteem sports for Veterans who had participated in the Veterans adaptive sports events for 5 to 10 years compared to those who participated for less than 5 years. A study of individuals with SCI (multiple sports) reported no correlation between level of activity, time from injury, level of injury, or age and scores on a community integration questionnaire. One study reported that each year of participation in adaptive sports was associated with an increase in employment through the first 10 years of participation.

Key Question 2

Fourteen research articles were eligible for our analysis of harms associated with adaptive sports participation: 4 RCTs, 1 cohort study, 7 cross-sectional studies, and 2 case series. There were 6 sports program studies and 8 sports activity participation studies.

There was little evidence of harms associated with adaptive sports participation, whether in formal program studies or in sports activity participation studies. Four of 6 program studies reported there were no injuries among participants. In the 2 other studies, the injuries were largely minor events. All but 1 of the sports activity participation studies enrolled wheelchair athletes (predominantly SCI); reported harms were shoulder and wrist pain. Overall, few adaptive sports or populations of interest were represented in the literature and few studies were designed to determine specific harms associated with an adaptive sports program.

Key Question 3

Thirty-seven studies, presented in 40 papers, reported on barriers (n=25), facilitators (n=15), and motivators (n=24) to participation in adaptive sports. Thirty-six of these were observational and 1 was of an experimental design (RCT). Among the observational studies, 14 were cross-sectional, 2 were cohort, 3 were conducted in focus groups, 10 were interviews, 1 was a narrative analysis, and 6 were of mixed methods. The questionnaires and surveys were either completed via mail or administered in person. Six studies reported exclusively on barriers, 3 on facilitators, 4 on motivators, and 23 on a mix of factors related to participation.

We used a modified version of the International Classification of Functioning and Disability Health framework (ICF) to conceptualize the reported barriers, facilitators, and motivators associated with participation in adapted sports. The framework includes the following categories: health conditions, body functions and structure, activity, participation, environmental factors, and personal factors.

Barriers to adaptive sports participation were similar across studies reporting on different medical conditions and different sports. Reported barriers were mainly due to physical environmental factors such as a lack of information, cost, accessibility, or transportation concerns. Personal barriers included fear of injury/pain, lack of time, and low self-esteem.

Reasons for either initiating participation or continuing participation in adaptive sports were similar. Commonly reported reasons for participation included social factors (social contacts, participation in society, interaction with others with similar disabilities) and personal beliefs (improved health/fitness, increased self-esteem/self-efficacy, improved skill, interest in new experiences).

SUMMARY AND DISCUSSION

Key Findings and Strength of Evidence

Key Question 1

Evidence for the effectiveness of adaptive sports ***programs*** is limited in quantity, quality, and applicability. Findings come largely from studies of EAAT in selected populations with PTSD (including US Veterans), MS, or CVA who agreed to participate in these programs. Many outcomes of interest were infrequently reported including self-esteem/perceived competence, community integration/social functioning, and employment. No studies reported on health care utilization.

Evidence for the effectiveness of adaptive ***sports activity participation*** is largely from observational studies enrolling selected individuals with SCI and involving multiple sports. We found no studies exclusively enrolling individuals with PTSD, CVA, TBI, MS, ALS, or hearing loss or deafness and few studies limited to a specific adaptive sport.

Key Question 2

There was little evidence of harms associated with adaptive sports programs or adaptive sports participation although few adaptive sports or populations of interest were represented in the literature. Few studies were designed to capture specific harms associated with participation.

Key Question 3

Barriers to participation were similar across sports and population and were mainly due to physical environmental factors including lack of information, cost, accessibility, and transportation concerns. Personal barriers included fear of injury or pain, lack of time, and low self-esteem. Facilitators of participation included social factors (social contacts, participation in society, interaction with others with similar disabilities) and personal beliefs (improved health/fitness, increased self-esteem and self-efficacy, improved skills, and new experiences).

Strength of Evidence

We assessed quality characteristics of included studies but did not formally rate risk of bias or strength of evidence. Approximately half of the included experimental and observational studies did not provide clearly defined inclusion criteria or indicated that participants were "selected". Many provided little demographic data to allow for a determination of the generalizability of findings. Most studies assessed outcomes using validated questionnaires or objective outcomes measures but, for questionnaires, response rates were less than 50% in 42% of the studies. Of the studies where it would be appropriate to adjust for confounding factors, there was evidence of adjustment in about 50%.

For the qualitative studies, approximately 66% reported congruity between theory and research methods. Nearly all did provide evidence of congruity between the research methods and the research questions, were considered to have adequately represented the participants, and included evidence of ethical approval of the study.

Applicability of Findings to the VA Population

Our findings have implications for VHA and Veterans in the design, development, implementation, and assessment of adaptive sports activities and programs. There appears to be some evidence that EAAT, in selected populations with PTSD, MS, or CVA who agreed to participate in these programs, can be beneficial. However, there is no information on resource use or the applicability to broader populations of individuals and/or program-specific details. In these populations there is little evidence of harm, though providing for broader populations (*eg,* those that are not interested in EAAT or with other medical conditions) should be done with caution and should be evaluated. Other sports activities, populations, and settings have a limited empiric base for program development and implementation. Future programs could be derived from existing programs, modified to specific populations and settings, and should undergo evaluation. Because there is general agreement that sport participation should be encouraged, future questions should examine how this can be done in populations with physical challenges that differ from those not requiring sport activity adaptation. Our findings also help categorize and describe important barriers and facilitators to participation that require additional evaluation and incorporation to ensure successful participation at acceptable costs.

Limitations

Limitations of the available literature include generally low quality of evidence (*ie,* non-randomized designs, small sample sizes, selected populations) and few studies for many of the adaptive sports and conditions of interest. Disabling conditions were often self-reported and little information was provided about severity of the condition, etiology, comorbidities, or participant demographics. Marked variation in populations, interventions, and outcomes assessment limited data pooling or even semi-quantitative assessment of effect consistency or applicability. Results from EAAT, golf, and fly-fishing programs for individuals with PTSD, MS, or history of CVA may not be generalizable to other sports and other populations. Few studies provided follow-up data to assess whether participation continued and/or whether benefits were maintained.

Participants in the studies included in our review likely had a high level of interest in sports participation (many having participated prior to injury/illness); individuals with severe illness or disability and comorbid conditions were typically excluded from the studies.

Common limitations of studies reporting harms were poor documentation and definition of adverse events. Sample sizes were generally low, and most sports activity participation studies lacked comparators. Potential harms associated with adaptive sports participation in many sports of interest or by many populations of interest are unknown

Research Gaps/Future Research

The Adaptive Sports Grant Program, facilitated and managed by NVSP&SE, may provide an opportunity for future research. The Grants Program supports entities with significant experience in managing a large-scale adaptive sports program, including programs affiliated with a National Paralympic Committee or a National Governing Body authorized to provide Paralympic sports and programs in which at least 50 persons with disabilities participate or the eligible participants reside in at least 5 different congressional districts. Federal agencies are encouraged to partner with non-federal entities to jointly create national, regional, and community-based programs that provide adaptive sports activities for disabled Veterans and members of the Armed Forces.

Our findings strongly support the need for rigorous design and outcome evaluation across a spectrum of individuals, health conditions, interventions, and settings. Specific recommendations pertaining to the key questions addressed are provided below.

Key Questions 1 and 2

Future research could address benefits and harms of participation for other adaptive sports and other medical conditions. Studies could be designed to assess whether effectiveness and harms vary by severity of condition, time since disability or diagnosis, skill level of the participants, or their age, gender, or race and participants could be followed to assess long-term outcomes. Standardized outcome measures should be used to assess a broad range of outcomes including health/wellness, daily functioning, health care utilization, and employment.

Ideally future research into benefit and harms would utilize randomized study designs with appropriate control groups. However, it may be difficult to recruit an adequate sample size, and funding for such research may be difficult to obtain.

Key Question 3

The understanding of barriers to and facilitators of participation would benefit from longitudinal studies that assessed the factors influencing regular participation over an extended period in the individual's life. Such work could be built into any new regional or national programs. The bulk of evidence reported addressed why people continued to participate in sports versus facilitators to assist individuals in initiating participation.

A gap in the evidence remains concerning the applicability and generalizability to larger populations, including a broader US population including those without an overt interest in sports participation, women, and racial and/or ethnic minorities. Several sports of interest including hand-cycling, para-triathlon, sled hockey, snowboarding, soccer, surfing, wheelchair fencing, and wheelchair lacrosse were not represented in the literature.

Conclusions

Evidence for the effectiveness of adaptive sports programs is largely from studies of EAAT in selected populations with a history of PTSD, MS, or CVA. Thus, the strength of evidence to inform developing, implementing, making available, and evaluating the effects of adaptive sports programs or informal adaptive sports participation is low. There is insufficient evidence for other adaptive sports or populations and it is unknown whether findings from a particular sport in a particular population are generalizable. There was little evidence of harms associated with adaptive sports program participation although, again, few adaptive sports or populations of interest were represented in the literature. Barriers to and facilitators of adaptive sports participation were similar across studies reporting on a broader range of medical conditions and adaptive sports. Future research could focus on other adaptive sports and populations, other outcomes including harms, and long-term follow-up to determine if participation is sustained and if benefits are maintained.

ABBREVIATIONS TABLE

Abbreviation	Definition
Medical Conditions	
ALS	amyotrophic lateral sclerosis
CVA	cerebrovascular accident/stroke
MS	multiple sclerosis
PTSD	post-traumatic stress disorder
SCI	spinal cord injury
TBI	traumatic brain injury
Other	
ADLs	activities of daily living
EAAT	equine-assisted activities and therapies
ICF	International Classification of Functioning and Disability Health
NVSP&SE	National Veteran Sports Programs and Special Events
NVWG	National Veterans Wheelchair Games
RCT	randomized controlled trial
VA	Department of Veterans Affairs
VHA	Veterans Health Administration
WSC	Winter Sports Clinic

EVIDENCE REPORT

INTRODUCTION

The term "adaptive sports" is used to describe a sport that has either been adapted specifically for persons with a disability or created specifically for persons with a disability.[1] For persons with physical disabilities, organized sports can be traced back to the early 1900s. However, opportunities expanded greatly in the post-World War II era when adaptive sports began to be used for rehabilitation of Veterans.[2] Many of the early programs were in downhill skiing but the range of available sports and opportunities for participation at all levels, from recreational to competitive, has broadened greatly.

Within the Department of Veterans Affairs (VA), the vision of the National Veteran Sports Programs and Special Events (NVSP&SE) office (http://www.va.gov/adaptivesports) is "to be leaders in the provision of adaptive sports and therapeutic arts programs that complement VA's rehabilitation system of care for Veterans and members of the Armed Forces with disabilities." The national rehabilitation events are intended to "provide opportunities for Veterans to improve their independence, well-being, and quality of life through adaptive sports and therapeutic arts programs." The programs offered include the National Veterans Wheelchair Games, the National Veterans Golden Age Games, the National Disabled Veterans Winter Sports Clinic, the National Veterans Summer Sports Clinic, the National Disabled Veterans T.E.E. (Training, Exposure, Experience) Tournament, and the National Veterans Creative Arts Competition and Festival. Partners in the programs include the Paralyzed Veterans of America, the Disabled American Veterans, and the American Legion Auxiliary, along with Veterans Service Organizations, corporate sponsors, individual donors, and community organizations. Veterans training for Paralympic and Olympic sports may qualify for a monthly assistance allowance and the NVSP&SE provides grants to support national or community-based adaptive sports programs with the goal of increasing the availability of adaptive sports activities for Veterans and Service Members.

The purpose of this report is to systematically review the available evidence on the benefits and harms of adaptive sports participation and the barriers to and facilitators of participation. With input from our Operational Partners and Technical Expert Panel members, the scope of the project was limited to the following medical conditions: amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), cerebrovascular accident/stroke (CVA), traumatic brain injury (TBI), or visual impairment or blindness. Further, the scope was limited to the adaptive sports listed in Table 1. The report was intended to guide the VHA in developing, making available, and evaluating regional and national adaptive sports programs for Veterans that go beyond general recommendations to participate in sports.

Table 1. Adaptive Sports Eligible for Inclusion in Evidence Review

Alpine skiing	Golf	Surfing
Archery	Hand-cycling	Swimming
Athletics/ Track & field	Kayaking/Canoeing	Table Tennis
Billiards	Nordic Skiing	Tennis (including Wheelchair Tennis)
Boccia (Bocci, Bocce)	Para-Triathlon	Weightlifting-Power Lifting
Climbing	Sailing	Wheelchair Basketball
Curling	Shooting	Wheelchair Fencing
Cycling	Sitting Volleyball	Wheelchair Lacrosse
Equine Assisted Activities and Therapies (EAAT)	Sled Hockey	Wheelchair Rugby
Fishing (any type)	Snowboarding	
Goalball	Soccer	

The key questions for the review were:

Key Question 1. What is the effectiveness of participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

Key Question 1a. Does the effectiveness vary by frequency/duration of adaptive sport program participation?

Key Question 1b. Do particular patient groups (*ie*, age range, gender, race, time since injury, time involved in adaptive sports, type and/or severity of disability) benefit more than others from adaptive sports participation?

Key Question 2. What are the potential harms of participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

Key Question 3. What are the known facilitators of and barriers to the participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

This review will be used by the Veterans Health Administration (VHA) national program offices for Physical Medicine and Rehabilitation Services, Prosthetic and Sensory Aids Services, Recreation Therapy, and NVSP&SE, as well as the offices under Rehabilitation and Prosthetic Services. The review will inform implementation efforts and enhance efforts to integrate all of

the VHA's rehabilitation programs that incorporate adaptive sports within their treatment plan and the national programs hosted by the NVSP&SE with the goal of advancing Veteran's access to and the utilization of adaptive sports as part of their ongoing rehabilitation.

METHODS

TOPIC DEVELOPMENT

The key questions and scope of this review were developed with input from the Operational Partners, Technical Expert Panel, and content experts from the Minneapolis VA Health Care System serving on our project team.

SEARCH STRATEGY

We searched MEDLINE from 1995 to July 2018 using Medical Subject Headings (MeSH) and key words for the adaptive sports and medical conditions of interest (Appendix A). We searched EMBASE, SPORTDiscus, and Rehabilitation and Sports Medicine Source using search strategies based on the MEDLINE strategy.

STUDY SELECTION

Citations were entered into Distiller SR (Evidence Partners). Titles were reviewed by a single investigator or research associate. Abstracts of titles identified as potentially eligible were reviewed independently by 2 reviewers with a citation moving to full-text review if either reviewer considered the citation eligible. At the full-text review, agreement of 2 reviewers was needed for study inclusion or exclusion. Disputes were resolved by discussion with input from a third reviewer, if needed.

Due to the large number of citations, we also used the DistillerAI (Artificial Intelligence) feature to complete an AI Audit review of titles. This features screens titles and produces a confidence score from 0 (not confident reference should be included) to 1 (very confident reference should be included) to predict the inclusion/exclusion status of a reference. This prediction is based on a variable test set of included and excluded references identified by a human reviewer. The 850 references identified by Distiller AI were reviewed at the abstract level by a review investigator.

For Key Question 1 and 2 we included intervention studies comparing participation in an adaptive sports program to usual care, no intervention, or other intervention among individuals with a medical condition of interest. We label these as “sports program studies”. To expand the number of potentially eligible studies and provide possible information for the development of future programs, we also included studies of individuals participating in organized adaptive sports activities although the activity wasn’t specifically implemented for the purpose of determining whether participation provided benefits or harms. We label these as “sports activity participation studies” – typically cross-sectional observational studies.

For Key Question 3 we included studies assessing facilitators of and barriers to participation in adaptive sports among individuals with a medical condition of interest.

At all levels of review, the inclusion and exclusion criteria were as follows.

Inclusion:

- Age 18 and older with 1 or more medical conditions of interest (ALS, limb amputation, hearing loss or deafness, MS, PTSD, spinal cord disorder, SCI, CVA, TBI, or visual impairment or blindness);
- Participation in 1 or more adaptive sports of interest (Table 1) at the community level or higher (to include adaptive sports programs that begin during inpatient rehabilitation and continue to an outpatient/community-based phase);
- Reporting an outcome of interest; *primary outcomes* of interest were a) clinically important changes in health and wellness, daily functioning, self-esteem, perceived competence, community reintegration, participation in social activities, participation in employment, mood//quality of life, and health care utilization; b) harms related to participation in adaptive sports; and c) barriers and facilitators related to adaptive sports participation; *secondary outcomes* were: a) participation in adaptive sports programs and b) improvement in physical health or PTSD scale scores.

Exclusion:

- Sports programs with modifications of equipment or environment/culture exclusively based on participant age;
- Individual fitness programs or other activities done outside of a program led by a coach or program director (exception – athlete training for competition);
- Study of a sport activity other than pre-defined sports of interest or where >75% of participants are involved in sport not of interest;
- Study of a group of individuals with condition not pre-defined as condition of interest or where >75% do not have a condition of interest;
- Rehabilitation programs with no “sport” component
- Study of “physical activity” levels where physical activity includes items like household work, gardening, volunteering outside the home (*ie*, studies of physical activity must have included a “sport” component);
- Engineering/modeling studies;
- Human performance laboratory studies.

DATA ABSTRACTION

We abstracted study design and demographic data from eligible studies including medical condition(s), age, gender, and time since injury/diagnosis; adaptive sport; and US Veteran status. We also abstracted primary and secondary outcomes of interest (see Inclusion, above).

QUALITY ASSESSMENT

We did not formally assess risk of bias of individual studies due to the many study design variants in the included literature. For each included study, we reviewed critical elements of either observational and experimental studies or qualitative studies based on checklists developed by the Joanna Briggs Institute (http://joannabriggs.org/) (Appendix B).

DATA SYNTHESIS

For Key Question 1, tables were developed by outcome and stratified by whether the study reported on an adaptive sport program ("sports program study") or provided a cross-sectional view of adaptive sport participants ("sports activity participation study"). Subgroups of interest included: time since injury or diagnosis, frequency/duration of participation, age, gender, race, and type and/or severity of disability.

For Key Question 2, we also report outcomes from adaptive sports program and sports activity participation studies.

For Key Question 3, the International Classification of Functioning, Disability, and Health (ICF) model was used to summarize motivators to participation in adaptive sports, facilitators of participation, and barriers to participation.

For all Key Questions, findings were narratively synthesized.

RATING THE BODY OF EVIDENCE

We did not formally rate the overall quality of the evidence due to heterogeneity of participants, adaptive sports, study designs, and outcomes assessed.

PEER REVIEW

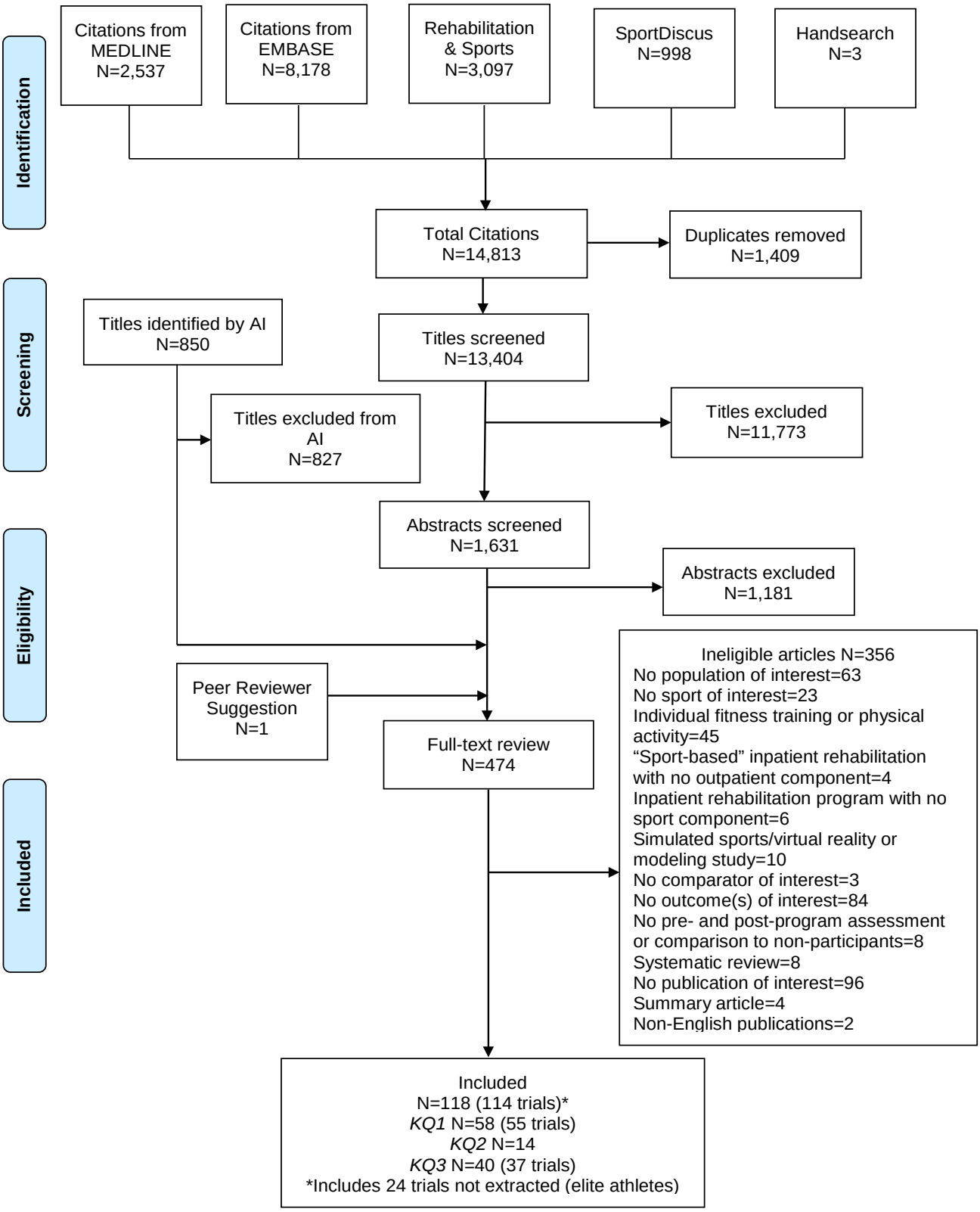
A draft version of this report was reviewed by content experts as well as clinical leadership. Reviewer comments and our responses are presented in Appendix C and the report was modified.

RESULTS

LITERATURE FLOW

Searching multiple bibliographic databases (1995-July 2018) and removing duplicate citations yielded a total of 13,404 citations (Figure 1). Review at the title level excluded nearly 12,000 citations, leaving 1,631 for abstract review. Over 1,100 abstracts were excluded resulting in 450 articles for full-text review with an additional 23 from DistillerAI. Following full-text review, there were 118 articles[3-120] eligible representing 114 studies. Twenty-four of the articles provided data on elite athletes (*eg*, Paralympians or World Championship participants). These articles were not included in our analyses as findings would be of limited applicability to the Veteran population.[5,6,17,24,27,28,36,39-41,47,48,51,56,62,71-74,84,88,91,98,111]

Figure 1. Literature Flow Chart



KEY QUESTION 1. What is the effectiveness of participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

KEY QUESTION 1A. Does the effectiveness vary by frequency/duration of adaptive sport program participation?

KEY QUESTION 1B. Do particular patient groups (*ie*, age range, gender, race, time since injury, time involved in adaptive sports, type and/or severity of disability) benefit more than others from adaptive sports participation?

Fifty-five studies reported an objective measure of at least 1 effectiveness outcome of interest. We grouped outcomes into 7 categories: Health and Wellness, Daily Functioning, Self Esteem/Perceived Competence, Mental Health (including mood, depression, and PTSD), Quality of Life, Community Reintegration/Social Participation, Employment, and Health Care Utilization. No studies reported a Health Care Utilization outcome. We also grouped studies into 2 groups: sports program studies and sports activity participation studies. Program studies described an adaptive sports program with multiple sessions over a period of a few days, a few weeks, or longer. Outcomes were often assessed both before and after participation in the program. Sports activity participation studies were typically cross-sectional, providing a one-time assessment of individuals who participate in organized adaptive sports activities although the activity wasn't specifically implemented for the purpose of determining whether participation provided benefits or harms. In both types of studies, there may or may not have been a comparator group.

Program Studies

Of the 25 program studies, 8 enrolled participants with PTSD including 6 studies with US Veterans.[13,14,38,58,64,75,93,113] There were 8 studies in participants with MS,[25,37,49,59,67,80,99,112,114] 5 studies of participants who had experienced a CVA,[11,12,96,97,119] 3 studies with SCI,[9,54,115] and 1 study of US Veterans with acquired disabilities associated with combat deployment.[70] The SCI studies included 1 study of participants with paraplegia or quadriplegia, another reporting injury level (cervical, thoracic, or lumbar), and 1 including both traumatic and non-traumatic SCI.

Adaptive sports included EAAT (11 studies, 3 with Veterans),[11,12,38,49,58,64,67,75,80,99,114] hiking or climbing (3 studies),[25,37,59,112] golf (3 studies),[96,97,119] fly-fishing (2 studies, both with US Veterans),[14,113] ski/snowboard (2 studies, 1 with US Veterans),[9,13] curling (1 study),[54] surfing (1 study with US Veterans),[93] and multiple sports (2 studies, 1 with US Veterans).[70,115] Medical conditions by adaptive sports included in the 25 program studies are shown in Table 2. Summary demographics are reported in Table 3 with detailed information in Appendix D, Table 1.

Table 2. Medical Conditions and Adaptive Sports – Number of Sports Program Studies Reporting Objective Effectiveness Outcomes

Adaptive Sport (number of studies)	Medical Condition (number of studies)					
	PTSD (8)	MS (8)	CVA (5)	SCI (3)	Multiple (1)	ALS, Limb Amputation, Hearing Loss, TBI, or Vision Loss (0)
EAAT (11)	4	5	2			
Hiking/ Climbing (3)		3				
Golf (3)			3			
Fishing (2)	2					
Ski/Snow-board (2)	1			1		
Curling (1)				1		
Surfing (1)	1					
Multiple (2)				1	1	

ALS=amyotrophic lateral sclerosis; CVA=cerebrovascular accident/stroke; EAAT=equine-assisted activities and therapies; MS=multiple sclerosis; PTSD=Post-traumatic stress disorder; SCI=spinal cord injury; TBI=traumatic brain injury

Table 3. Summary Demographics – Sports Program Studies (k=25)

Characteristics	Categories	Number of Studies[a]
Age (mean or median)	>50 years	12
	25-49 years	12
	<25 years	0
Gender	100% Male	0
	75-99% Male	6
	50-74% Male	8
	25-49% Male	6
	<25% Male	3
Time from Injury or Diagnosis (mean or median)	>10 years	3
	5-10 years	8
	<5 years	3

[a]Studies reporting mean or median values for characteristic

Programs ranged from 2 days to 45 weeks. The 45-week study involved 6 months of training for a hiking trip with 4 months follow-up after the trip.[25,37] Six studies, each lasting less than 1 week, were structured with all-day activities (fly-fishing, skiing, snowboarding, kayaking, or various wheelchair sports).[9,13,14,70,113,115] One study described a 5-day, one hour per day program of EAAT.[75] The remaining studies described programs of EAAT, golf, climbing, or curling, ranging

from 4 to 24 weeks, most occurring once per week for between 30 minutes and 2 hours. Program details are provided in Appendix D, Table 2.

Study designs varied and included 6 randomized controlled trials[11,54,58,97,112,114] and 4 nonrandomized controlled trials.[12,13,96,99] The remaining studies were pre-post designs. Sample sizes were small with 5 studies of 10 or fewer participants, 12 studies of 11 to 20 participants, 6 studies of 21 to 50 participants, and 2 studies with more than 50 participants. Thirteen studies were done in the US,[13,14,38,58,64,67,70,75,93,99,113,115,119] 1 in Canada,[97] 2 in South America,[11,12] and 9 in Europe.[9,25,37,49,54,59,80,96,112,114] Of the US studies, 8 specifically enrolled Veterans.[13,14,58,64,70,75,93,113]

Effectiveness Outcomes by Sport

Table 4 provides a summary of effectiveness outcomes from program studies organized by sport. Outcomes data are reported in Appendix D, Tables 3 to 9. Some studies may have reported more than 1 outcome in a particular cell (*eg*, more than 1 quality of life measure). Red symbols represent studies with a control group and indicate similar (↔) or statistically significantly different (↑) outcomes between groups following the intervention period. All differences favored the intervention group. Black symbols are from studies with no comparator group and indicate a significant or non-significant change from baseline. Some studies did not report results in a way that allowed a determination of significance (*eg*, 3 of 8 participants reported improvement); those studies are counted in the number of studies reporting a particular outcome category but denoted as “no outcomes data”.

Equine Assisted Activities and Therapies (EAAT)

Outcomes from EAAT programs were reported for individuals with PTSD, MS, or a history of CVA. Various forms of EAAT for individuals with PTSD were consistently associated with improved mental health outcomes (including overall mental health, depression, PTSD, and anxiety symptoms).[11,38,58,64,75] Three of the 4 studies of EAAT for individuals with PTSD enrolled exclusively US Veterans.[58,64,75]

EAAT may be associated with improved balance[80,99] and decreased fatigue[114] in those with a history of MS.

Program participation was not associated with changes in pain or overall health for individuals with PTSD,[38] MS,[114] or history of CVA.[11]

Other outcomes associated with EAAT programs in individuals with PTSD, MS, or history of CVA were infrequently reported. There were no reports of worsening of any outcomes associated with program participation.

Hiking/Climbing

Findings from 3 studies of hiking and/or climbing programs for individuals with MS suggest that program participation was not associated with changes in different aspects of health and wellness including balance,[59] fatigue,[37] and cognitive function.[112] Daily functioning,[37] self-esteem,[37] and depression[112] outcomes were reported by 1 study with no apparent association.

Golf

Golf programs for individuals with a history of CVA may be associated with improved balance[97,119] although 1 study found no significant difference in balance between golf training and social communication training.[96] There is little reporting of other outcomes including a measures of cognitive function,[96] daily functioning (walking task),[119] depression symptoms,[96] or impact of sickness on quality of life.[97]

Fly-fishing

Two fly-fishing programs for Veterans with PTSD symptoms were associated with improvements in PTSD symptoms and other mental health outcomes.[14,113] There was limited reporting of association with improved sleep quality[113] and improved daily functioning.[14]

Ski/Snowboard, Curling, Surfing, Multiple Sport Program

There was limited reporting of outcomes for these activities with studies including individuals primarily with PTSD or SCI. Available studies suggest that ski/snowboard,[13] surfing,[93] and multiple sports[70] programs may be associated with improved mental health symptoms including PTSD symptoms, depression, and mood. There was limited reporting of other outcomes. No studies report an association between program participation and a worsening of outcomes.

Effectiveness Outcomes by Population

Outcomes organized by population are summarized in Table 5. Detailed outcome data is reported in Appendix D, Tables 3 to 9.

PTSD

Among 8 studies of individuals with PTSD (7 of which enrolled exclusively Veterans), EAAT,[38,58,64,75] fly-fishing,[14,113] ski/snowboard,[13] and surfing[93] programs were associated with improved mental health outcomes. Two studies had a comparator group. A non-randomized trial of a ski/snowboard program for 17 Veterans and their significant others reported significant reductions in PTSD symptoms in the program participants compared to baseline.[13] The ski/snowboard group had a change in symptoms that was significantly greater than individuals who did not participate in the program. A randomized trial of a therapeutic horseback riding program for 29 US Veterans with PTSD found significant reductions in mean PCL-M scores at 3 weeks compared to baseline and at 6 weeks compared to 3 weeks for Veterans in the intervention group.[58] There were no significant changes in the wait list group and mean scores at all time points were above 50.

Few studies reported other outcomes of interest. No study reported that program participation was associated with worse outcomes.

Multiple Sclerosis

For individuals with MS, EAAT programs were generally associated with improved balance.[80,99,114] There was little reporting of other outcomes. Similarly, there was little reporting of outcomes associated with hiking/climbing programs. No study reported that program participation was associated with worse outcomes.

CVA

For individuals with a history of CVA, golf therapy programs were associated with improved balance in 1 study[97] while 2 studies reported no association.[96,119] Both EAAT[11] and golf therapy[97] programs may be associated with improved quality of life but overall few studies reported outcomes of interest.

Spinal Cord Injury

For individuals with SCI, few outcomes were reported to allow assessment of effectiveness of ski/snowboard programs,[9] wheelchair curling,[54] or multi-sport programs.[115] None of the studies enrolled exclusively US Veterans with SCI.

Multiple Conditions

A single pre-post study of a multisport program (water sports, fly-fishing, or winter sports) for 18 US Veterans with a variety of post-combat disabilities reported that program participation was associated with improved self-esteem, mood, and quality of life.[70]

Table 4. Summary of Sports Program Studies that Reported Patient-Centered Effectiveness Outcomes by Sport[a]

Sport (k=number of studies)[b] Population/ Condition	Health and Wellness (k=17)	Daily Functioning (k=10)	Self-Esteem/ Perceived Competence (k=5)	Mental Health (Mood, Depression, PTSD) (k=13)	Quality of Life (k=7)	Community Integration/ Participation in Social Activities (k=5)	Employment (k=0)
EAAT (k=11)[a] PTSD k=4 MS k=5 CVA k=2	***PTSD k=2 (****1 with no outcomes data)* PHQ-9 Somatic ↔ AUDIT-C ↑ ***MS k=5*** *(2 with no outcomes data* POMA ↑↔ BBS ↑↑ VAS (pain) ↔ FSS ↑ ***CVA k=2*** SF-36 General Health ↔ SF-36 Pain ↔ BBS ↔	***PTSD k=1*** SF-36 Function ↔ ***MS k=3*** *(2 with no outcomes data)* BI ↔ ***CVA k=2*** SF-36 Function ↑ FAC ↔	***PTSD*** *k=1* GPSES ↔	***PTSD k=4*** *(1 with no outcomes data)* PCL-S ↑ PCL-M ↑ PCL-5 ↑ BSI ↑ PHQ-9 ↑ GAD ↑ ***MS k=1*** *(no outcomes data)* ***CVA k=1*** SF-36 Mental Health ↑	***PTSD k=1*** SWLS ↔ ***MS k=1*** MSQoL-54 ↑ ***CVA k=1*** SF-36 ↑	***PTSD k=2*** *(1 with no outcomes data)* SELSA ↔ ***MS k=1*** *(no outcomes data)* ***CVA k=1*** SF-36 Social ↔	
Hiking/Climbing (k=3) MS k=3	k=3 Postural sway ↔ FSMC ↔ MFIS ↑ Cognitive executive function ↔	k=1 MSWS ↔	k=1 ESES ↔	k=1 CES-D ↔			
Golf (k=3) CVA k=3	k=3 BBS/BBT ↔↑ CMPCI ↑ BTT ↑	k=1 FFB ↔		k=1 CES-D ↔	k=1 SIP ↑		

Sport (k=number of studies)[b] **Population/ Condition**	**Health and Wellness (k=17)**	**Daily Functioning (k=10)**	**Self-Esteem/ Perceived Competence (k=5)**	**Mental Health (Mood, Depression, PTSD) (k=13)**	**Quality of Life (k=7)**	**Community Integration/ Participation in Social Activities (k=5)**	**Employment (k=0)**
Fly-fishing (k=2) PTSD k=2	k=1 PSQI ↑	k=1 WRFIS ↑	k=1 BNSLS ↔	k=2 PHQ-9 ↑ PCL-M ↑↑ BSI-18 ↑ PANAS ↑	K=1 LSS ↔		
Ski/Snowboard (k=2) PTSD k=1 SCI k=1			***SCI k=1*** PSI-6 ↑	***PTSD k=1*** PCL-M & C ↑	***PTSD k=1*** RDAS ↔		
Curling (k=1) SCI k=1	k=1 MFRT ↔	k=1 SCIM-III ↔					
Surfing (k=1) PTSD k=1				k=1 PCL-M ↑ MDI ↑			
Multiple sports (k=2) SCI k=1 Multiple k=1			***Multiple k=1*** PCS ↑	***Multiple k=1*** POMS-Brief ↑	***Multiple k=1*** WHOQoL ↑	***SCI k=1*** LMS Social ↔ Stimulus avoidance ↑	

[a]Each arrow represents one study reporting that outcome; some studies may have reported more than one outcome per category
[b]Some studies reported patient counts of change without outcomes data; significance of findings could not be determined and those studies are not included in counts; some studies reported a between group difference for some outcomes and a pre-post difference for other outcomes
↔ No significant difference between intervention and comparator groups
↔ No significant change from pre- to post-intervention (no comparator group)
↑ significant improvement for intervention group vs comparator group
↑ significant improvement from pre- to post-intervention (no comparator group)

ADL=activities of daily living; AIMS=Athletic Identity Measurement Scale; AUDIT-C=Alcohol Use Disorders Identification Test; BBS/BBT=Berg Balance Scale/Test; BI=Bartel Index; BDI=Beck Depression Inventory; BNSLS=Basic Needs Satisfaction in Life Scale; BSI=Brief symptom Inventory; BTT=Block-Tapping task; CES-D=Center for Epidemiologic Studies Depression Scale; CHART=Craig Handicap Assessment Reporting Technique; CIQ=Community Integration Questionnaire; CMPCI=Chedoke-McMaster Postural Control Inventory; CSES=Coping Self Efficacy Scale; CVA=cerebrovascular accident or stroke; DERS=Difficulties in Emotion Regulation Scale; EAAT=equine assisted activities and therapies; EDSS=Expanded Disability Status Scale; EMG=Electromyography; ES=effect size; ESES=Exercise Self-Efficacy Scale; FAC=Functional Ambulation Category Scale; FES-I=Falls Efficacy Scale – International; FFB=Functional Fitness Battery; smoking cessation, alcohol control); FGA=Functional Gait Assessment; FSMC=Fatigue Scale for Motor and Cognition; FSS=Fatigue Severity Scale; GAD=Generalized Anxiety Disorder Scale; GPSES=General Perceived Self-Efficacy Scale; HADS=Hospital Anxiety and Depression Scale; IMF=Index of Muscle Function; IPAQ = International Physical Activity Questionnaire; LAM=Leisure Attitude Measurement; LiSat-9= Life Satisfaction Questionnaire-9 item; LMS=Leisure Motivation Scale; LSS=Leisure Satisfaction Scale; MAS=Modified Ashworth Scale; MDI=Major Depression Inventory; MRT=Mental Rotation Test; MFISt=Modified Fatigue Impact Scale (total); MFRT=Modified Functional Reach Test; MS=multiple sclerosis; MSQoL-54=Multiple Sclerosis Quality of Life-54; MSWS=Multiple Sclerosis Walking Ability Scale; NAB=Mazes subtest of Executive module from the Neuropsychosocial assessment battery; NR=not reported; NS=not statistically significant; NVWG=National Veterans Wheelchair Games; OR=odds ratio; PANAS=Positive Affect and Negative Affect Schedule; PCL-C=PTSD Checklist-Civilian; PCL-M=PTSD Checklist-Military; PCL-S=PTSD Checklist-Specific; PCL-5=PTSD checklist for Diagnostic and Statistical Manual of Mental Disorders (DSM-5); PCI=Proactive Coping Inventory; PCS=Perceived Competence Scale; PHQ=Patient Health Questionnaire; POMA=Performance Oriented Mobility Assessment; POMS(-B)=Profile of Mood States (-Brief); PS=Participation Scale; PSDQ=Physical Self-Description Questionnaire; PSFS=Patient-Specific Functional Scale; PSI-6=Physical Self Inventory; PSQI=Pittsburgh Sleep Quality Inventory; PSS=Perceived Stress Scale; PTGI=Posttraumatic Growth Inventory; PTSD=post-traumatic stress disorder; QLI=Quality of Life Index; RDAS=Revised Dyadic Adjustment Scale; RNL=Reintegration to Normal Living Index; RSES=Rosenberg Self-Esteem; SCI=spinal cord injury; SCIM=Spinal Cord Independence Measure; SCL-90-R=Symptom Checklist 90; SDS=self-rating depression scale; SEADL=Self-Efficacy for Activities of Daily Living; SELSA=Social and Emotional Loneliness Scale for Adults – short version; SF-36=Medical Outcomes Study Short Form; SIP=Sickness Impact Profile; SOQ=Sport Orientation Questionnaire; SOT=Sensory Organization Test; STAI=State-Trait Anxiety Inventory; SWLS-Satisfaction with Life Scale; TEOSQ=Task and Ego Orientation in Sport Questionnaire; TOLnm=Tower of London Test (number of moves);TOLtt=Tower of London Test (total time); TUG=timed up and go; WRFIS=Walter Reed Functional Impairment Scale; WSC=Winter Sports Clinic (Veterans); VAS=Visual Analog Scale; WHOQoL-BREF=World Health Organization Quality of Life-Brief; WUSPI=Wheelchair User's Shoulder Pain Index

Table 5. Summary of Sports Program Studies that Reported Patient-Centered Effectiveness Outcomes by Population[a]

Population (k=number of studies)[b] Sport	Health and Wellness (k=17)	Daily Functioning (k=10)	Self-Esteem/ Perceived Competence (k=5)	Mental Health (Mood, Depression, PTSD) (k=13)	Quality of Life (k=7)	Community Integration/ Participation in Social Activities (k=5)	Employment (k=0)
PTSD (k=8) EAAT k=4 Fly-fishing k=2 Ski/snowboard k=1 Surfing k=1	***EAAT k=2*** *(1 with no outcomes data)* PHQ-9 ↔ AUDIT-C ↑ ***Fly-fishing k=2*** PSQI ↑	***EAAT k=1*** SF=36 Function ↔ ***Fly-fishing k=2*** WRFIS ↑	***EAAT k=1*** GPSES ↔ ***Fly-fishing k=1*** BNSLS ↔	***EAAT k=4*** *(1 with no outcomes data)* PCL-M ↑ PCL-S ↑ PCL-5 ↑ GAD ↑ PHQ-9 ↑ BSI ↑ ***Fly-fishing k=2*** PCL-M ↑↑ PHQ-9 ↑ BSI ↑ PANAS ↑ ***Ski/snowboard k=1*** PCL-M ↑ ***Surfing k=1*** PCL-M ↑ MDI ↑	***EAAT k=1*** SWLS ↔ ***Fly-fishing k=1*** LSS ↔ ***Ski/snowboard k=1*** RDAS ↔	***EAAT k=1*** SELSA ↔	

Population (k=number of studies)[b] **Sport**	**Health and Wellness (k=17)**	**Daily Functioning (k=10)**	**Self-Esteem/ Perceived Competence (k=5)**	**Mental Health (Mood, Depression, PTSD) (k=13)**	**Quality of Life (k=7)**	**Community Integration/ Participation in Social Activities (k=5)**	**Employment (k=0)**
Multiple Sclerosis (k=8) EAAT k=5 Hiking/ climbing k=3	***EAAT k=5*** *(2 with no outcomes data)* BBS ↑↑ POMA ↑↔ FSS ↑ VAS (pain) ↔ ***Hiking/ climbing k=3*** Postural sway ↔ MFIS ↑ FSMC ↔ Cognitive executive function ↔	***EAAT k=1*** BI ↔ ***Hiking/ climbing k=1*** MSWS ↔	***Hiking/ climbing k=1*** ESES ↔	***EAAT k=1*** *(no outcomes data)* ***Hiking/ climbing k=1*** CES-D ↔	***EAAT k=1*** MSQoL-54 ↑	***EAAT k=1*** *(no outcomes data)*	
CVA (k=5) EAAT k=2 Golf k=3	***EAAT k=2*** SF-36 General Health ↔ BBS ↔ SF-36 Pain ↔ ***Golf k=3*** BBS ↔↑↔ CMPCI ↑ BTT ↑	***EAAT k=2*** SF-36 Functional Capacity ↑ FAC ↔ ***Golf k=1*** FFB ↔		***EAAT k=1*** SF-36 Mental Health ↑ ***Golf k=1*** CES-D ↔	***EAAT k=1*** SF-36 ↑ ***Golf k=1*** SIP ↑	***EAAT k=1*** SF-36 Social ↔	
Spinal Cord Injury (k=3) Ski/snowboard k=1 Curling k=1 Multiple k=1	***Curling k=1*** MFRT ↔	***Curling k=1*** SCIM III ↔	***Ski/snowboard k=1*** PSI-6 ↑			***Multiple k=1*** LMS Social ↔ Stimulus avoidance ↑	

Population (k=number of studies)[b] Sport	Health and Wellness (k=17)	Daily Functioning (k=10)	Self-Esteem/ Perceived Competence (k=5)	Mental Health (Mood, Depression, PTSD) (k=13)	Quality of Life (k=7)	Community Integration/ Participation in Social Activities (k=5)	Employment (k=0)
Multiple (k=1) Multiple k=1			k=1 PCS ↑	k=1 POMS-B ↑	k=1 WHOQoL ↑		

[a]Each arrow represents one study reporting that outcome; some studies may have reported more than one outcome per category
[b]Some studies reported patient counts of change without outcomes data; significance of findings could not be determined and those studies are not included in counts; some studies reported a between group difference for some outcomes and a pre-post difference for other outcomes
↔ No significant difference between intervention and comparator groups
↔ No significant change from pre- to post-intervention (no comparator group)
↑ significant improvement for intervention group vs comparator group
↑ significant improvement from pre- to post-intervention (no comparator group)
Abbreviations – See Table 4

Sports Activity Participation Studies

The sports activity participation studies enrolled primarily SCI (20 studies)[3,10,16,43,45,50,61,66,76,77,81,86,87,95,100-102,105-107,110,120] or mixed conditions (5 studies)[33,42,63,103,117] populations. Participants were typically involved in multiple sports (20 studies).[16,33,35,43,45,50,61,63,66,76,81,86,87,95,101-103,105-107,110,117] Table 6 displays the distribution of medical conditions by adaptive sports in the 30 sports activity participation studies. Table 7 summarizes demographic characteristics. Additional study information is reported in Appendix D, Table 1.

Table 6. Medical Conditions and Adaptive Sports – Number of Sports Activity Participation Studies Reporting Objective Effectiveness Outcomes

Adaptive Sport (number of studies)	Medical Condition (number of studies)				
	SCI (20)	Vision Impairment (4)	Multiple (5)	Limb amputation (1)	ALS, Hearing Loss, MS, PTSD, CVA, TBI (0)
Multiple (20)	15 (1 quadriplegia or paraplegia, 7 tetraplegia or paraplegia, 1 paraplegia, 5 not specified)	1	4 (SCI, limb amputation, TBI, PTSD, vision impairment, MS)[a]		
Wheelchair Rugby (4)	4 (1 quadriplegia, 2 (tetraplegia, 1 not specified)				
Wheelchair Basketball (2)	1 (not specified)		1 (SCI or limb amputation)		
Soccer (2)		1		1	
Goalball (1)		1			
Cycling (1)		1			

[a]multiple conditions in each study
ALS=amyotrophic lateral sclerosis; CVA=cerebrovascular accident/stroke; PTSD=post-traumatic stress disorder; MS=multiple sclerosis; SCI=spinal cord injury; TBI=traumatic brain injury

Table 7. Summary Demographics – Sports Activity Participation Studies (k=30)

Characteristics	Categories	Number of Studies[a]
Age (mean or median)	>50 years	2
	25-49 years	23
	<25 years	0
Gender	100% Male	9
	75-99% Male	13
	50-74% Male	6
	25-49% Male	0
	<25% Male	1
Time from Injury or Diagnosis (mean or median)	>10 years	12
	5-10 years	2
	<5 years	1

[a]Studies reporting mean or median values for characteristic

Most sports activity participation studies were cross-sectional in design. Some studies included a comparator group – typically non-sport participants with the same physical condition or athletes from the same sport without the physical condition.

The number of participants enrolled ranged from 11[8] to 1034.[105] There were 11 studies with fewer than 50 enrolled, 4 studies with 50 to 100 enrolled, 13 studies with 101 to 500 enrolled, and 2 studies with more than 500 enrolled.

Eight studies were done in the US,[16,45,49,61,63,66,100,103] 3 in Canada,[33,76,86,87] 2 in Australia/New Zealand,[3,43] 2 in Japan,[77,81] 1 in South America,[35] and the remaining 14 in Europe. Of the 8 US studies, 4 specifically enrolled US Veterans.[18,61,63,103]

Effectiveness Outcomes by Sport

Table 8 provides a summary of effectiveness outcomes from sport activity participation studies organized by sport. Outcomes data are reported in Appendix D, Tables 3 to 9. As noted above, some studies may have reported more than 1 outcome in a particular cell and some studies did not report results in a way that allowed a determination of significance (denoted as "no outcomes data").

Wheelchair Basketball, Wheelchair Rugby, Goalball, Cycling, Soccer

With few studies focused exclusively on any of these sports, there is little information on outcomes among participants in the sports. No outcome was reported by more than 1 study. There was no evidence that adaptive sports participation was associated with worsening of any outcome.

Table 8. Summary of Sports Activity Participation Studies that Reported Patient-Centered Effectiveness Outcomes by Sport[a]

Sport (k=number of studies)[b] Population/ Condition	Health and Wellness (k=7)	Daily Functioning (k=4)	Self-Esteem/ Perceived Competence (k=9)	Mental Health (Mood, Depression, PTSD) (k=7)	Quality of Life (k=10)	Community Integration/ Participation in Social Activities (k=5)	Employment (k=3)
Wheelchair basketball (k=2) SCI k=1 Multiple k=1		***SCI k=1*** (no outcomes data)		***Multiple k=1*** SCL-90-R ↑		***Multiple k=1*** PS ↑	
Wheelchair rugby (k=4) SCI k=4			k=1 SEADL ↑ (transferring items only)	k=2 (no outcomes data)	k=1 LiSat-9 ↔		
Goal ball (k=1) Visual impairment k=1	k=1 Stability ↔						
Cycling (k=1) Visual impairment k=1			k=1 AIMS ↑				
Soccer (k=2) Limb amputation k=1 Visual impairment k=1	***Limb amputation k=1*** (no outcomes data) ***Visual impairment k=1*** Center of pressure displacement ↔				***Limb amputation k=1*** (no outcomes data)		

Sport (k=number of studies)[b] Population/ Condition	Health and Wellness (k=7)	Daily Functioning (k=4)	Self-Esteem/ Perceived Competence (k=9)	Mental Health (Mood, Depression, PTSD) (k=7)	Quality of Life (k=10)	Community Integration/ Participation in Social Activities (k=5)	Employment (k=3)
Multiple (k=20) SCI k=15 Visual impairment k=1 Multiple k=4	***SCI k=2*** Dyspnea ↑ Chronic disease risk ↔ ***Visual impairment k=1*** FES-I ↑ Static balance ↑ ***Multiple k=1*** QLI Health ↔	***SCI k=1*** CHART Physical independence ↑ ***Visual impairment k=1*** Gait speed ↔	***SCI k=5*** (2 with no outcomes data) AIMS ↑ TEOSQ self-efficacy Task ↑ Barrier ↑ PSDQ Global Esteem ↑ Physical ↑ ***Multiple k=3*** (2 with no outcomes data) RSES ↑	***SCI k=4*** (1 with no outcomes data) CES-D ↔ SDS ↑ HADS ↑ STAI State ↔ STAI Trait ↑↑ POMS ↑	***SCI k=4*** (1 with no outcomes data) LiSat-9 ↑ SWLS ↑ RNL ↑ ***Multiple k=4*** (1 with no outcomes data) QLI Total ↔ SWLS ↑ WHOQoL ↑↑	***SCI k=3*** CHART Social Integration ↑ CIQ ↑↔ ***Multiple k=1*** (no outcomes data)	***SCI k=2*** Study-determined measures ↑↔ ***Multiple k=1*** Study-determined measure ↑

[a]Each arrow represents one study reporting that outcome; some studies may have reported more than one outcome per category
[b]Some studies reported patient counts of change without outcomes data; significance of findings could not be determined and those studies are not included in counts; some studies reported a between group difference for some outcomes and a pre-post difference for other outcomes
↔ No significant difference between intervention and comparator groups
↔ No significant change from pre- to post-intervention (no comparator group)
↑ significant improvement for intervention group vs comparator group
↑ significant improvement from pre- to post-intervention (no comparator group)
Abbreviations – See Table 4

Multiple Sports

Among studies enrolling participants from a variety of sports, the most commonly studied population was individuals with SCI. Participation in adaptive sports for individuals with SCI was consistently associated with greater self-esteem,[95] athletic identity,[106,107] and self-efficacy,[86,87] and higher quality of life.[45,76,105] Results were less consistent for mental health, community integration, and employment outcomes. Sports participation was associated with better balance outcomes for individuals with visual impairment.[35] Two of 3 studies assessing quality of life reported sports participation by individuals with various medical conditions was associated with higher quality of life.[63,117]

Effectiveness Outcomes by Population

Outcomes organized by population are summarized in Table 9.

Spinal Cord Injury

Fifteen of 20 studies enrolling individuals with SCI included participants from a variety of sports. As noted above, participation in adaptive sports was consistently associated with greater self-esteem[95] and self-efficacy[86,87] and better quality of life.[45,76,105] Results were less consistent for mental health and community integration outcomes and there was little reporting for health and wellness or daily functioning. Two studies reported employment outcomes. A survey of 302 US Veterans, diagnosed with paraplegia or tetraplegia, asked about working or volunteering status before and after participation in the NVWG.[61] Veterans working after the Games were more likely to report that participation in the Games had a positive influence on employment compared to those not working (RR 1.52 [95%CI 1.21, 1.92]). Another study enrolled 149 adults with chronic SCI; 47% were US Veterans.[16] Participation in organized sports (including basketball, tennis, snow skiing, water sports, bowling, hand cycling, fishing, and others) was positively associated with employment defined as either full- or part-time paid work or regular volunteer work (OR 2.04 [95%CI 0.98, 4.69]). Results were not reported for the Veteran group alone. Few outcomes were reported for individuals with SCI participating in wheelchair basketball or wheelchair rugby.

Visual Impairment

Among individuals with visual impairment, sports participation (either goalball or soccer) was associated with improved balance[35] although separate studies of these sports reported no difference in balance measures between blind goalball players and blind sedentary individuals[7] or blind soccer players and sighted soccer players.[26] There were few reports of other outcomes.

Limb Amputation

A single study of 11 soccer players with limb amputations reported a balance score and a quality of life measure but without a comparison (either pre-participation or another group).[8]

Multiple Conditions

In studies of individuals with multiple medical conditions, participation in adaptive sports was associated with higher quality of life in 2 of 3 studies reporting.[63,117] Other outcomes were reported by a single study.

Table 9. Summary of Sports Activity Participation Studies that Reported Patient-Centered Effectiveness Outcomes by Population[a]

Population (k=number of studies)[b] Sport	Health and Wellness (k=7)	Daily Functioning (k=4)	Self-Esteem/ Perceived Competence (k=9)	Mental Health (Mood, Depression, PTSD) (k=7)	Quality of Life (k=10)	Community Integration/ Participation in Social Activities (k=5)	Employment (k=3)
SCI (k=20) (includes tetraplegia, quadriplegia, and paraplegia) Wheelchair rugby k=4 Wheelchair basketball k=1 Multiple k=15	***Multiple k=2*** Dyspnea ↑ Chronic disease risk ↔	***Wheelchair basketball k=1*** (no outcomes data) ***Multiple k=1*** CHART Physical Independence ↑	***Wheelchair rugby k=1*** SEADL ↑ (transferring items only) ***Multiple k=2*** (2 with no outcomes data TEOSQ self-efficacy Task ↑ Barrier ↑ PSDQ Global Esteem ↑ Physical ↑	***Wheelchair rugby k=2*** (no outcomes data) ***Multiple k=6*** (3 with no outcomes data) CES-D ↔ SDS ↑ STAI Trait ↑↑ STAI State ↔ POMS ↑	***Wheelchair rugby k=1*** LiSat-9 ↔ ***Multiple k=4*** (1 with no outcomes data) LiSat-9 ↑ RNL ↑ SWLS ↑	***Multiple k=3*** CIQ ↔↑ CHART Social Integration ↑	***Multiple k=2*** Study-determined measures ↑↔
Visual impairment (k=4) Goalball k=1 Tandem cycling k=1 Soccer k=1 Multiple k=1	***Goalball k=1*** Stability ↔ ***Soccer k=1*** Center of pressure displacement ↔ ***Multiple k=1*** FES-I ↑ Static balance ↑	***Multiple k=1*** Gait speed ↔	***Tandem cycling k=1*** AIMS ↑				

Population (k=number of studies)[b] **Sport**	**Health and Wellness (k=7)**	**Daily Functioning (k=4)**	**Self-Esteem/ Perceived Competence (k=9)**	**Mental Health (Mood, Depression, PTSD) (k=7)**	**Quality of Life (k=10)**	**Community Integration/ Participation in Social Activities (k=5)**	**Employment (k=3)**
Limb amputation (k=1) Soccer (k=1)	k=1 (no outcomes data)				k=1 (no outcomes data)		
Multiple (k=5) Wheelchair basketball k=1 Multiple k=4	***Multiple k=1*** QLI ↔	***Multiple k=1*** (no outcomes data)	***Multiple k=3*** (2 with no outcomes data) RSES ↑	***Wheelchair basketball k=1*** SCL-90-R ↑	***Multiple k=4*** (1 with no outcomes data) QLI ↔ SWLS ↑ WHOQoL ↑↑	***Wheelchair basketball k=1*** PS ↑ ***Multiple k=1*** (no outcomes data)	***Multiple k=1*** Study-determined measure ↑

[a]Each arrow represents one study reporting that outcome; some studies may have reported more than one outcome per category
[b]Some studies reported patient counts of change without outcomes data; significance of findings could not be determined and those studies are not included in counts; some studies reported a between group difference for some outcomes and a pre-post difference for other outcomes
↔ No significant difference between intervention and comparator groups
↔ No significant change from pre- to post-intervention (no comparator group)
↑ significant improvement for intervention group vs comparator group
↑ significant improvement from pre- to post-intervention (no comparator group)
Abbreviations – See Table 4

KEY QUESTION 1A. Does the effectiveness vary by frequency/duration of adaptive sport program participation?

Few studies (and no sports activity participation studies) reported information to address Key Question 1a. Two studies of individuals with SCI reported that athletic identity scores were higher for those who participated in sports more hours per week.[102,106,107] No specific sports were noted. Another study of 1,034 athletes with SCI reported that more hours per week of participation was a significant predictor of higher athletic identity.[105] Those who were able to participate in their "favorite" sport also had higher athletic identity scores. Scores did not differ for team and individual sport athletes.

One study reported measures of depression, anxiety, and mood in adaptive sports participants and non-participants.[81] The study enrolled individuals diagnosed with tetraplegia, paraplegia, or quadriplegia with multiple sports represented. Scores on the Self-rating Depression Scale (SDS) were significantly lower in "high active" individuals compared to inactive or "low active" individuals. State Trait Anxiety Inventory (STAI) state anxiety scores did not differ between "high active" and inactive individuals but STAI trait anxiety scores were significantly lower in the "high active" group. There were lower Profile of Mood States (POMS) Depression subscale scores for the "high active" group compared to the inactive and "low active" groups. A similar pattern was observed for the POMS Vigor subscale. In a study of tetraplegic wheelchair rugby players, CES-D scores were higher in those who practiced no more than once per week but did not differ significantly from those who practiced 2 or more time per week.[100]

KEY QUESTION 1B. Do particular patient groups (*ie*, age range, gender, race, time since injury, time involved in adaptive sports, type and/or severity of disability) benefit more than others from adaptive sports participation?

Similarly, few studies (and sports activity participation studies) reported information to address Key Question 1b. A sports activity participation study enrolling 221 US Veterans participating in the NVWGs, the US Olympic Committee Warrior Games, or the National Veterans Summer Sport Clinic reported that self-esteem scores were significantly higher for Veterans who participated in sport, exercise, or recreation for 5 to 10 years compared to those participating for 1 to 5 years or less than 1 year. Scores were also higher for Veterans who participated in individual sports compared to team sports.[63]

A sports activity participation study enrolling 50 visually impaired or "able-bodied" tandem cycling participants reported that, among the visually impaired group, scores were similar regardless of time when vision failed (from birth vs later in life) or hours per week training (9-12 vs 13-16).[108]

The studies cited for Key Question 1a enrolling individuals with SCI reported that athletic identity scores were significantly higher for male athletes.[102,106,107] No specific sports were noted. In the third study, male gender was a significant predictor of higher athletic identity.[105]

A study of 234 wheelchair athletes (marathon or basketball) reported that ego orientation scores from the Task and Ego Orientation in Sport Questionnaire (TEOSQ) were higher in wheelchair marathoners, but both ego and task orientation were similar for male and female athletes.[100]

There was no correlation between level of activity, time from injury, level of injury, or age and CIQ scores in a study of 30 individuals with SCI participating in team (wheelchair rugby, wheelchair basketball, boccia, and unihockey) or individual (wheelchair racing, power lifting, swimming, wheelchair fencing, and alpine skiing) sports.[110]

A study from the US enrolling wheelchair rugby and wheelchair basketball players, 81% with SCI, reported that each additional year of participation in adaptive sports was significantly associated (P=.03) with an increase in employment rate through the first 10 years of participation.[66] The association weakened with participation beyond 10 years. The study included Veterans but did not report separate results for the Veteran group.

KEY QUESTION 2. What are the potential harms of participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

Fourteen research articles were eligible for our analysis of harms associated with adaptive sports participation: 4 RCTs, 1 cohort study, 7 cross-sectional studies, and 2 case series. There were 6 program studies[37,54,58,59,80,114] and 8 sports activity participation studies.[4,10,19,34,44,53,57,118] In all studies enrolling individuals with MS,[37,59,80,114] participants in the treatment and comparator groups (if present) had exacerbations and neurological worsening during study participation; these events were excluded from our analysis as they could not be attributed solely to adaptive sports participation.

Sports Program Studies

The 6 program studies reporting harms are summarized in Table 10. Additional information about the studies is reported in Appendix D, Table 1. The 4 eligible RCTs/CCTs were studies of specific sport programs, with 3 of the 4 involving EAAT[58,80,114] and the fourth a study of wheelchair curling.[54]

Two studies of EAAT for individuals with MS[80] or US Veterans with PTSD/TBI[58] reported no adverse events during the programs. Program durations were 5[58] and 10[80] weeks. A 12-week RCT of EAAT for individuals with MS reported that 44% of the EEAT and 27% of the standard care group experienced an adverse event or serious adverse event. This study included extensive monitoring and used a broad definition of adverse events. The “accidence” incidence when comparing the groups was 13% (4/30 experiencing 5 events) in the intervention group and 3% (1/37) in the control group.[114] The RCT of 4 weeks of wheelchair curling for individuals with SCI reported no adverse events.[54]

The 2 other program studies involved mountain climbing (total of 10 months of training and hiking)[37] or indoor climbing (5-week program)[59] for individuals with MS. The mountain climbing program reported 3 minor medical events[37] while the indoor climbing study reported on fatigue noting no excessive fatigue.[59]

Table 10. Injuries Reported in Sports Program Studies

Author, Year, Study Type	Disability	Sport Duration of Participation	Injured n/N (%)	Comparator	Comparator Injured n/N (%)	Injury Type
D'hooghe 2014[37] Cohort	Multiple Sclerosis	Mountain Climbing Duration NR	3/9 (33%)	N/A	N/A	Medical event (minor)
Herzog 2018[54] RCT	SCI	Wheelchair Curling Duration NR	0/6 (0%)	No curling	0/7 (0%)	Adverse event
Johnson 2018[58] RCT	PTSD, TBI	Therapeutic Horseback Riding Duration NR	0/15 (0%)	Wait List	0/14 (0%)	Injuries
Jolk 2015[59] Case Series	Multiple Sclerosis	Indoor Climbing Duration 0 (no prior experience)	0/6 (0%)	N/A	N/A	Fatigue
Muñoz-Lasa 2011[80] CCT	Multiple Sclerosis	Therapeutic Horseback Riding Duration 0 (no prior experience)	0/12 (0%)	Physiotherapy	0/15 (0%)	Adverse event
Vermöhlen 2018[114] RCT	Multiple Sclerosis	Hippo-therapy Duration NR	14/32 (44%) Total=16 events[a]	Standard Care	10/37 (27%) Total=16 events[b]	Adverse event or Serious adverse event

[a]Infection (6), Psychological condition (1), Orthopedic condition (3), Accidence (5), Metabolic condition (1)
[b]Infection requiring hospitalization (1), Other infection (12), Psychological condition (2), Accidence (1)
N/A=not applicable; PTSD=post-traumatic stress disorder; RCT=randomized controlled trial; SCI=spinal cord injury; TBI=traumatic brain injury

Sports Activity Participation Studies

Three of the 8 sports activity participation studies (Table 11) compared injury or adverse event rates between groups.[4,44,118] Akbar et al calculated the relative risk of injury comparing sport participants (predominantly wheelchair basketball) to those that denied playing sports. The relative risk for developing rotator cuff injury was 2.09 (95%CI 1.68-2.59) for SCI wheelchair users that played overhead sports compared to those not playing sports.[4]

An earlier study compared shoulder pain among individuals with SCI participating in multiple sports (51% basketball, 26% tennis, 23% rugby, 19% racing, 5% skiing, 5% handcycling, *etc*).[44] Individuals who trained at least 3 hours/week, were involved in at least 3 competitions each year, and used a sport-modified wheelchair were considered athletes. The athlete group was more likely to experience shoulder pain (OR 2.15 [95%CI 1.11, 4.18]).

You et al looked at rotator cuff injuries in table tennis (n=19) and archery (n=16) participants with SCI.[118] The mean numbers of rotator cuff related diseases were similar in the 2 groups.

There were differences in the pattern of injury for the different sports and for the playing/non-playing arm (table tennis) or the bow or draw arm (archery).

Several studies reported injuries during training. Bauerfeind et al reported injuries among 14 male wheelchair rugby players during 9 months of training camps and tournaments.[10] There were 102 injuries that did not require medical consultation (muscle strains, muscle overloads, abrasions, subluxations, and bruises). Four injuries did require physician consultation including a multi-joint spinal overload, a supraspinatus muscle strain, bruised ribs, and olecranon bursitis. Two of these 4 injuries were a result of a fall during play and 2 were degenerative.

Table 11. Injuries Reported in Sports Activity Participation Studies

Author, Year, Study Type	Disability	Sport Duration of Participation	Injured n/N (%)	Comparator Duration of Participation	Comparator Injured n/N (%)	Injury Type
Akbar 2015[4] Cross-sectional	SCI	Wheelchair Overhead Sports Duration NR	78/103 (76%)	No sports	70/193 (36%)	Rotator cuff tear
Bauerfeind 2015[10] Case series	SCI	Wheelchair Rugby 7 years (mean)	4/14 (29%)	N/A	N/A	Injury requiring physician consult
Boninger 1996[19] Cross-sectional	SCI and limb amputation	Wheelchair Racing 12.6 years (mean)	8/12 (67%) 4 bilateral 4 unilateral	N/A	N/A	Carpal tunnel syndrome physical examination
Curtis 1999[34] Cross-sectional	SCI and others	Wheelchair Basketball Duration NR	33/46 (72%)	N/A	N/A	Shoulder pain
Fullerton 2003[44] Cross-sectional	SCI	Any Wheelchair Sport 10 years (mean)	67/172 (39%)	Non-athletes	56/85 (66%)	Shoulder pain
Haykowsky 1999[53] Cross-sectional	Visual Impairment	Powerlifting 5 years (mean)	4/11 (36%)	N/A	N/A	Powerlifting-related injury
Jackson 1996[57] Cross-sectional	SCI	Wheelchair Basketball Duration NR	17/33 (52%)	N/A	N/A	Carpal or median neuropathy
You 2016[118] Cross-sectional	SCI	Wheelchair Table Tennis 17 years (mean)	RC diseases (mean) Playing arm: 2.2 Non-playing arm: 2.3	Wheelchair Archery 12 years (mean)	RC diseases (mean) Bow arm: 2.3 Draw arm: 2.5	Shoulder tendinopathy

N/A=not applicable; NR=not reported; RC=rotator cuff; SCI=spinal cord injury

Another study described injuries among 11 visually impaired athletes (9 males) training for a powerlifting competition.[53] During a 12-month period, 4 of 11 (36%) reported a powerlifting-related injury requiring medical intervention and discontinuation of training for more than 1 day. The injury rate corresponded to 0.11 injuries per 100 hours of training.

A study of shoulder pain in 46 female wheelchair basketball players found that 72% (33/46) experienced shoulder pain since wheelchair use.[34] Although 52% had shoulder pain at the time of the survey, only 11 % reported that it limited their activities in the past week. Medical conditions included SCI (39%), limb amputation (9%), lower extremity musculoskeletal and neuromuscular disabilities (28%), polio (13%), and spina bifida (11%) and average years of wheelchair use was 13. Scores on the Wheelchair User's Shoulder Pain Index (WUSPI) were higher (indicating greater pain) for ambulatory athletes (mean score 20.0) compared to nonambulatory athletes (mean score 12.8) and, among medical conditions, highest among athletes with limb amputations (mean score 35.7). It was not possible to determine whether wheelchair basketball was a significant factor.

Upper limb nerve entrapment was the focus of a study of 12 wheelchair racers.[19] The sample included 11 males (92%), mean age was 33 years, and 75% participants had experienced a SCI. On physical exam, 67% (8/12) had signs of carpal tunnel syndrome – 4 bilateral and 4 unilateral. Five (42%) had signs of ulnar nerve entrapment – 4 bilateral and 1 unilateral.

A final study assessed the prevalence of carpal tunnel syndrome in 33 male wheelchair basketball players (58% paraplegia, 18% limb amputation).[57] Ten (30%) met criteria for clinical carpal tunnel syndrome. With electrodiagnostic testing, carpal tunnel syndrome was confirmed in 70% (7/10). Based on the electrodiagnostic results, median neuropathy was identified in 52% (17/33).

Summary of Findings

Harms associated with the limited number of adaptive sports programs reporting were infrequent and generally not serious. Four of 6 sports program studies reported there were no injuries among participants. The other 2 studies involved a total of 41 selected individuals with MS participating in either rock climbing or hippotherapy. All but 1 of the sports activity participation studies enrolled wheelchair athletes (predominantly SCI); reported harms were shoulder and wrist pain. Overall, few adaptive sports or populations of interest were represented in the literature and few studies were designed to determine specific harms associated with an adaptive sports program.

KEY QUESTION 3. What are the known facilitators of and barriers to the participation in adaptive sports programs among individuals with amyotrophic lateral sclerosis (ALS), limb amputation, hearing loss or deafness, multiple sclerosis (MS), post-traumatic stress disorder (PTSD), spinal cord disorder, spinal cord injury (SCI), stroke/cerebrovascular accident (CVA), traumatic brain injury (TBI), or visual impairment or blindness?

We used a modified version of the International Classification of Functioning and Disability Health framework (ICF) to conceptualize the reported barriers, facilitators, and motivators associated with participation in adapted sports.[121,122] The ICF is the World Health Organization framework for measuring interrelated factors of health and disability at individual and population levels. The model was designed to be a classification system of health and health-related domains used to describe changes to an individual's capacity in daily life. The framework includes the following domains: health conditions, body functions and structure, activity, participation, environmental factors, and personal factors (Table 12).

Table 12. ICF Domains

Domain	Definition
Health conditions	disease, disorder, injury, or trauma
Body functions	physiological functions of body systems
Body structures	anatomical parts of the body
Activity	execution of a task or action by individual
Participation	involvement in adaptive sports
Environmental factors	physical, social factors external to individuals with positive or negative influence on performance in society, capacity to execute actions or tasks, or on bodily functions or structure
Personal factors	background features of an individual's life that comprise features that are not a part of a health condition or health state

https://www.icf-research-branch.org/icf-training/icf-e-learning-tool

The ICF model attempts to explain a person's ability to function as a result of a health condition or disability. Disabilities exist in the context of environmental and personal factors outside of the person. An individual's functioning in life and the extent to which they are disabled are a result of an interaction between health conditions and both personal and environmental factors, which can interact with body function, activities, and participation in a continuous manner.

Previous reviews have utilized the ICF model to explain the factors affecting sports participation for people with disabilities.[121,123] For the purposes of this review, facilitators were factors or components that contributed to initial participation in adapted sports, while motivators contributed to continued participation. Barriers were factors or aspects of living with a disability that prevented or limited regular sports participation.

Thirty-seven studies, represented in 40 papers, reported on barriers (n=25), facilitators (n=15), and motivators (n=24) to participation in adaptive sports. Thirty-six of these were observational and 1 was of an experimental design (RCT).[54] Among the observational studies, 15 were surveys

or questionnaires,[21,22,55,60,78,82,83,85,89,92,94,102,105-107,116] 3 were conducted in focus groups,[15,25,37,65] 10 were interviews,[23,29-32,52,68,69,90,104,109] 1 was a narrative analysis,[79] 1 reviewed registration forms and participation logs,[18] and 6 were of mixed methods.[20,33,46,64,76,103] The questionnaires and surveys were either completed via mail or administered in person. Six studies reported exclusively on barriers,[18,22,76,83,89,105] 3 on facilitators,[25,37,79,103] 4 on motivators,[54,64,68,78] and 23 on a mix of factors related to participation.

Barriers to Participation in Adaptive Sports (Figure 2)

Health Conditions and Participation

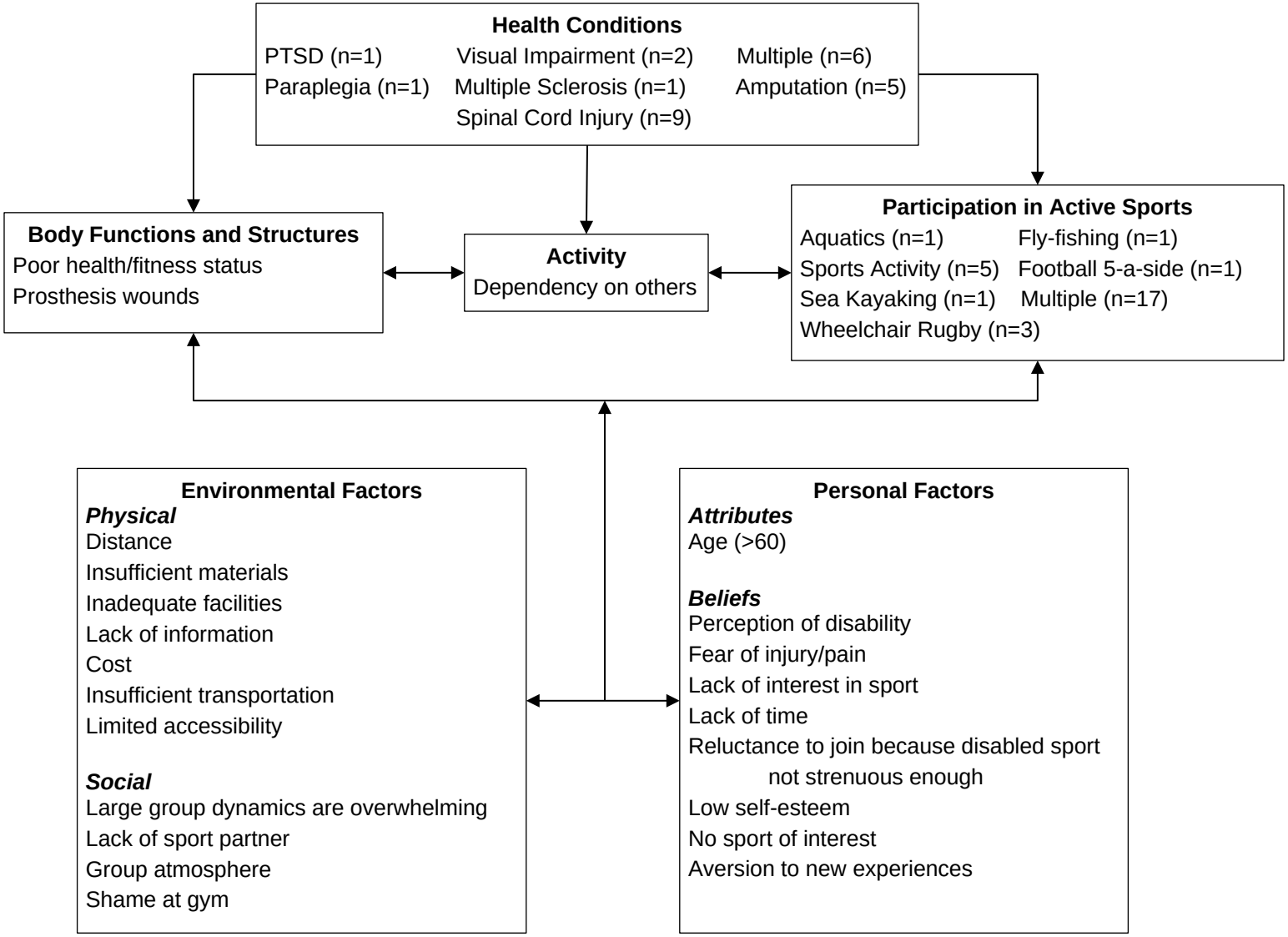
Nine of the 25 studies reporting on barriers exclusively recruited participants with SCI (N=3029),[76,82,92,102,104-107,109,116] 1 enrolled participants with SCI or Guillain-Barré disease (n=33),[85] 5 enrolled individuals with limb amputations (N=1113),[21-23,60,69] 2 enrolled participants with visual impairment (N=738),[55,76] and a further 6 enrolled participants across a range of diagnoses (N=329).[18,20,33,65,83,89] Other diagnoses, with a single study each, included MS (n=45),[32] PTSD (n=27),[15] and paraplegia (n=24).[94]

Sports investigated in the reports included aquatics,[32] fly-fishing,[15] sea kayaking,[109] 5-a-side football,[76] and wheelchair rugby.[20] Twenty studies enrolled participants from a variety of sports.[18,21-23,33,55,60,65,69,82,83,85,89,92,94,102,104-107,116]

Body Structure or Function

Twelve of the 25 articles reported that impaired body structure or function was a barrier to sports participation. Ten studies that focused mainly on individuals with limb amputations, SCI, or multiple diagnoses reported that poor physical health was a barrier to participation in sports.[21,23,60,69,83,89,94,102,104,105] Other impairments that prevented participation in sports included poor health/fitness status, muscle tone dysfunction, fatigue, difficulty sleeping, unmet medical needs, poor health from being a smoker, and physical pain from stump wounds. One study that investigated sports participation among individuals with limb amputations who participated in a range of sports reported that wounds from prosthesis use caused players to stop playing.[60]

Figure 2. Barriers to Adaptive Sports Participation



Activity

Six studies reported that limitations due to activity factors prevented participation in sports.[23,55,83,85,89,106,107] Bragaru et al reported that many feared becoming a burden to others.[23] Participants also reported that dependency on others to complete basic activities of daily living (ADLs) was a key factor that also limited their sports participation. In some cases, the dependent participant needed help with ADLs but lacked a personal care assistant so participation in sports was challenging.[83,85]

Environmental Factors

Physical

Twenty-three of the 25 studies reported physical environmental barriers. Of these, 11 studies reported that a lack of information about the availability of adapted sports opportunities prevented participation.[21,32,55,65,69,82,83,85,89,104,109] Cost was another prohibitive factor cited by 12 studies enrolling participants with a wide range of diagnoses.[21,33,55,60,65,82,83,89,94,102,104,106,107] Other physical barriers to participation included the travel distance required to practice sports, insufficient transportation, insufficient materials, inadequate facilities, and accessibility limitations such as limited team numbers or limited facilities. Bragança et al reported that often the clothing available for adaptive sports is insufficient and can be a barrier to participation.[20]

Social

Eleven studies reported social barriers to participation.[15,22,23,55,69,82,83,94,102,104,109] The lack of a sporting partner and feeling shame from others were common themes mentioned by sports participants. Other social barriers reported included issues with a group atmosphere ranging from difficulties with inclusion, frustration with team sports, and issues with a highly competitive environment. Bragaru et al reported that some participants disliked participating in sports with only other disabled team members.[23]

Personal Factors

Eighteen studies reported personal factors that prevented participation in sports. Personal factors were subdivided into attributes and beliefs.

Attributes

Three studies, 2 focused on individuals with limb amputations and 1 on multiple diagnoses, reported that advanced age (>60 years) prevented participants from engaging in sports.[22,60,83]

Beliefs

Fifteen studies reported that personal beliefs interfered with regular sports participation. The fear of pain or further injury was supported by 7 studies.[23,55,60,65,76,83,94] A lack of time to participate regularly in sports was the most frequently reported barrier and was mentioned in 8 studies across a variety of disabilities.[23,55,65,83,85,102,104,106,107] Four studies reported that participants believed their disability, which included visual impairment, SCI, or multiple diagnoses, made them unable to engage in sport.[55,65,76,92] One study, in participants with SCI, stated that they did not participate in sports before their injury and therefore the experience was completely novel to them post-injury.[116] This caused many of them to be unaccustomed to the rigors associated with

training. Other beliefs reported include no sport of interest available and a lack of interest in sporting in general. One study reported that some participants with MS felt a reluctance to join MS-specific aquatics classes because of the belief that disabled sport is not strenuous enough.[32]

Facilitators and Motivators of Participation in Adaptive Sports (Figure 3 and Appendix Figure 1)

Health Conditions and Participation

Thirty-one studies (N=5873), in 34 papers, reported on facilitators and motivators influencing participation in adaptive sports, whether this was in a formalized program or through individual or group participation in "non-programmatic" sporting activity. Health conditions varied across studies. Eight enrolled participants with SCI (N=1918),[54,82,92,102,104,106,107,109,116] 5 with limb amputations (N=338),[21,23,29,60,69] 2 with PTSD (N=95),[15,79] 2 with visual impairment (N=807),[55,90] 2 with MS (N=54),[25,32,37] and 9 with multiple conditions (N=337).[20,30,31,33,46,52,64,65,85,103] In addition to those previously listed, other health conditions included PTSD, TBI, tetraplegia, quadriplegia, CVA, and paralysis. No studies indicated that health condition influenced participation in adaptive sports. Adaptive sports represented also varied across studies, including fly-fishing, aquatics, hiking, wheelchair rugby and basketball, curling, and EAAT, among others.

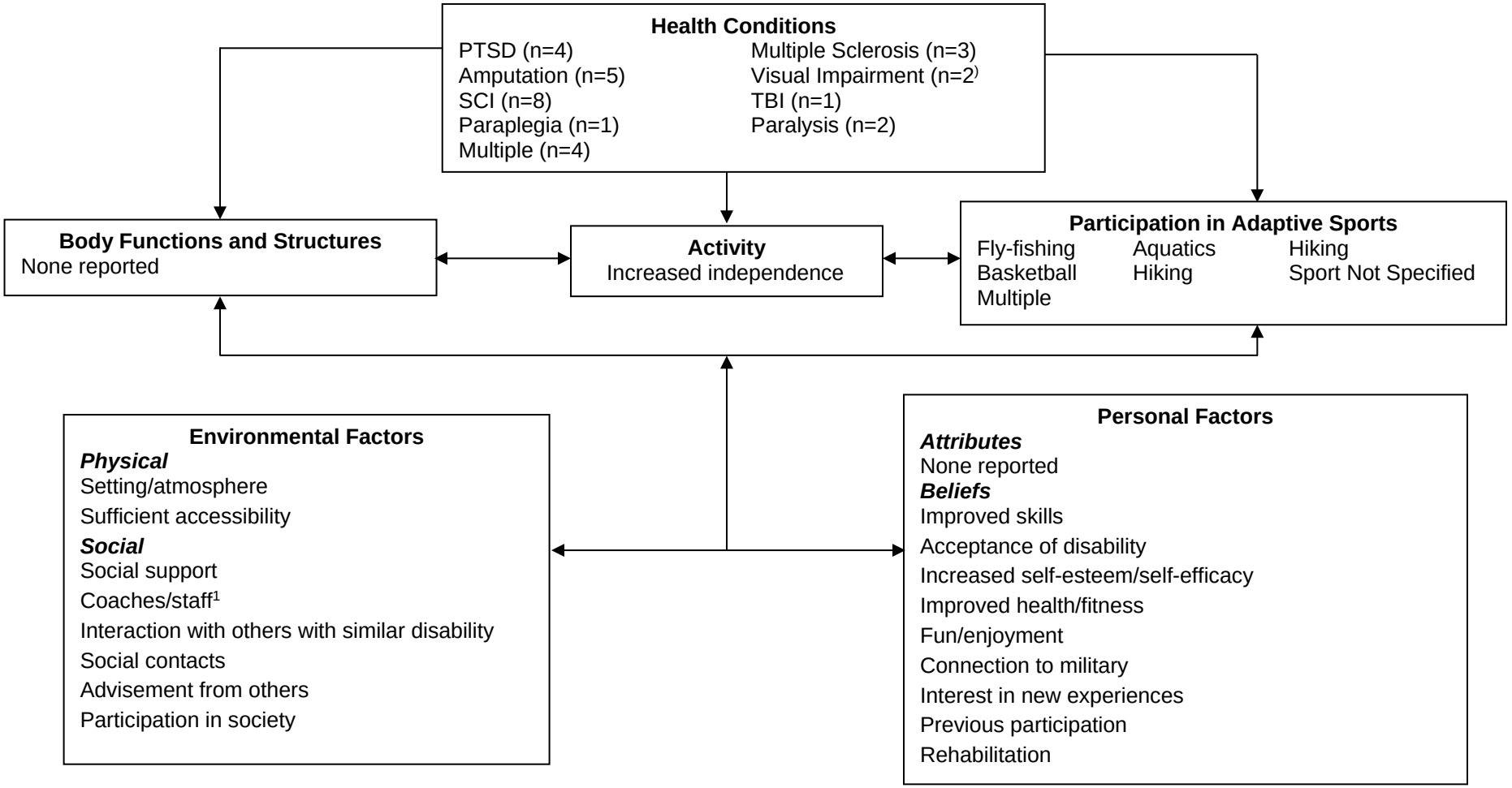
Body Functions and Structures

No studies reported on body function and structures as a facilitator or motivator to adaptive sports participation.

Activity

Independence was identified as both a facilitator and motivator to participation in adaptive sports. Seven studies, 1 conducted after a hiking expedition to Machu Picchu,[25,37] found re-gaining and experiencing independence was a factor reported for initiating and maintaining participation among participants with multiple conditions, including visual impairment, SCI, and MS.[29,52,55,78,103,109] The ability to maintain ADLs was also reported by multiple studies as a motivator for continued participation in adaptive sports.[23,33,46,60,65,68,94,103]

Figure 3. Facilitators of Adaptive Sports Participation



Environmental Factors

Physical

In comparison to the study by Kars et al[60] that found that problems with the prosthesis and prosthesis costs limited participation in sports, individuals with lower limb amputations in the study by Bragaru et al identified their prosthetic device to be a facilitating factor for participation.[23] The participants considered sports an opportunity to make the best use of their prosthetic devices. There were no factors related to body function and structures reported as motivators.

Nine studies identified the physical setting or atmosphere and accessibility to be factors influencing the initiation and continuation of adaptive sports.[15,25,30-32,37,46,65,79,92,109] A supportive and stress-free environment with safety measures in place was also identified as an important factor in 2 studies, 1 in hikers with MS and the other in sea kayakers with SCI.[25,37,109]

One study cited access to an active sports club membership as a facilitating factor to participation among persons with SCI.[92] Two other studies, 1 on aquatics for people with MS and 1 in persons with SCI across multiple sports, reported safety, specifically a minimal risk of falls and overheating, as motiving factors for continued involvement.[32,82] Participants in the study by Chard attributed continued participation to a welcoming environment that created a sense of belonging.[32] Nam et al reported transportation as both motivator and barrier, as most participants used owner-driven cars to attend sports club.[82]

Social

Identified by 18 studies, meeting people and/or maintaining social contacts was the most reported facilitator and motivator for participation in adaptive sports.[20,21,23,29,32,46,55,60,64,65,68,78,85,94,102,103,106,107,116] Twelve studies,[15,23,30-32,46,52,68,69,90,103,104,109] including 1 in Veterans with PTSD and 1 in Veterans with a limb amputation, identified interacting with others with similar disabilities as a facilitating and motivating factor,[15,69] while 11 studies cited participation in society.[25,30-33,37,55,64,69,85,94,103,109]

Advisement from others such as therapists and doctors (11 studies),[21,23,32,46,60,68,69,82,94,102,116] and social support from friends, family, and adaptive sports groups (12 studies)[15,23,25,32,37,55,65,69,78,79,82,104,109] were also commonly reported as being facilitators and motivators to adaptive sports participation. At the same time, a lack of information from healthcare providers was also reported as a barrier in number of studies.

Group atmosphere, including the use of exercise partners,[29,68,69,78] as well as improved relationships,[30,31,33,52,103] were identified solely as motivators to participation in 4 studies each. The use of a buddy system was also identified as encouraging continued participation among scuba divers with SCI or limb amputation.[29] In addition, 3 studies reported the opportunity to be a part of a team as a motivator for multiple sports, including wheelchair rugby, wheelchair basketball, and boccia, among tetraplegics and individuals with limb amputations.[68,69,78]

Sporner et al surveyed Veterans with various health conditions at the NVWG and the WSC and found 77% reported improved personal relationships and 73% reported increased communication skills with friends and family following participation.[103] Two studies also found that the presence

of coaches and/or staff with some physical therapy or sports training was a motivator, helping to ensure safety among adaptive sports participants.[32,65]

Personal Factors

Attributes

No studies reported on attributes as a facilitator or motivator to adaptive sports participation.

Beliefs

Increasing self-esteem and self-efficacy[15,23,29-31,33,46,55,64,65,68,69,78,85,102-104,106,107,109,116] and improving and/or maintaining health and fitness [21,23,25,32,33,37,46,52,54,55,60,65,68,69,79,85,94,102-104,106,107,109,116] were the most-identified beliefs associated with participation in adaptive sports. Sports represented in these studies included fly-fishing, aquatics, sea kayaking, scuba diving, wheelchair rugby, curling, hiking, EAAT, and others; health conditions included MS, SCI, PTSD, limb amputation, and visual impairment, among others.

Fun and enjoyment,[15,21,23,29-32,46,55,78,94,102,106,107,109,116] as well as an interest in new experiences,[30,31,52,55,65,68,69,78,79,102,103,106,107,109] were the most-reported reasons for taking part in various adapted sports among participants with limb amputations, PTSD, TBI, SCI, and visual impairment.

Participants in 8 studies reported acceptance of disability contributed to the initiation and/or continuation of adaptive sports.[15,23,29,52,55,69,94,109] Four of these studies were among Veterans with various health conditions, including PTSD and limb amputation, participating in fly-fishing or other adaptive sports.[15,52,69,103] Carin-Levy reported the freedom from impairment and feeling of freedom among scuba divers with SCI or a limb amputation.[29] Improving sports skills was also reported as a facilitator and motivator to participation.[15,33,52,78,90,103,109]

Attitude toward adaptive sports was an important motivating factor reported in 2 studies enrolling individuals with TBI, SCI, paraplegia, tetraplegia, or limb amputation.[33,52] Participants in these studies reported feeling a sense of belonging and an expansion on what they valued in life through adaptive sports. In addition, being a role model to others was reported as a motivating factor in 1 study.[65]

Five studies in SCI, paraplegic, and visually impaired populations, among others, reported rehabilitation as the reason for adaptive sports initiation or continuation.[20,55,85,94,116] Previous participation in sports, including connection to a recreation center and the ability to perform sports enjoyed before disability, were identified as facilitators and motivators to adaptive sports in participants with a limb amputation, SCI, or visual impairment.

Findings Focused on Veterans

Barriers

Health Conditions and Participation

Two studies reported barriers to participation focused on US Veterans (N=55).[15,69] Bennett et al studied 28 Veterans with PTSD participating in a fly-fishing expedition.[15] Littman et al

completed semi-structured interviews with 27 Veterans with lower limb amputation asking about factors influencing their participation in sports.[69]

Environmental Factors

Physical. The study enrolling Veterans with limb amputations noted a lack of information about sporting opportunities and insufficient transportation as physical barriers to participation.[69]

Social. Bennett reported that a large group size was a barrier for Veterans with PTSD so fly-fishing groups were intentionally limited to 2 or 3 people.[15] Littman et al identified the lack of a sporting partner and feelings of shame, brought on by others, as social barriers to participation in sports after limb amputation.[69] These factors were supported by other studies of civilian populations.

Body Functions and Structures

No studies in US Veterans reported on body function and structures as a barrier to adaptive sports participation.

Activity

No studies in US Veterans reported on activity level factors as a barrier to adaptive sports participation.

Personal

Attributes. No studies in US Veterans reported on physical attributes as a barrier to adaptive sports participation.

Beliefs. Littman et al reported that a fear of further injury and/or pain and having low self-esteem were beliefs that prevented Veterans with limb amputation from participating in sports.[69]

Facilitators and Motivators

Health Conditions and Participation

Six studies focused on disabled US Veterans, with 2 reporting on both facilitators and motivators.[52,69] Health conditions represented in these studies included PTSD, TBI, lower limb amputation, visual impairment, MS, and SCI. Studies varied by sport with 3 studies assessing participation in multiple sports. Two studies were conducted at a fly-fishing retreat for Veterans with PTSD[15,79] and 1 looked at EAAT for Veterans with multiple health conditions.[64]

Body Function and Structures

No studies in US Veterans reported on body functions and structure as a facilitator or motivator to adaptive sports participation

Activity

Increased independence was a factor reported for initiating and maintaining participation among Veterans in 3 studies.[52,79,103] Sporner also identified the ability to maintain activities of daily living as a motivator to participation in various adaptive sports.[103]

Environmental Factors

Physical. Two studies among Veterans with PTSD, conducted at a fly-fishing retreat, considered the natural environment and peaceful setting of the outdoors as contributors to Veteran participation.[15,79]

Social. Among Veterans with SCI, limb amputation, visual impairment, and MS, 79% reported "increased friends" as a motivating factor to continue involvement in adaptive sports.[103] Two studies, 1 in Veterans with PTSD and 1 in Veterans with limb amputation, identified interacting with others with similar disabilities as a facilitating and motivating factor.[15,69]

Littman et al reported the opportunity to be a part of a team as a motivator for multiple sports, including wheelchair rugby, wheelchair basketball, and boccia, among tetraplegics and individuals with limb amputations.[69] In addition, Sporner et al found 77% of Veterans at the NVWG or WSC reported improved personal relationships and 73% reported increased communication skills with friends and family.[103]

Personal Factors

Attributes. No studies in US Veterans reported on physical attributes as a facilitator or motivator to adaptive sports participation.

Beliefs. In US Veterans, 4 studies identified increasing self-esteem and self-efficacy[15,64,69,103] and 3 studies identified improving and/or maintaining health and fitness[52,69,103] to be beliefs associated with participation in adaptive sports. New experiences, acceptance of disability, and improving skills also contributed to the initiation and/or continuation of adaptive sports in Veterans.[15,52,69,79,103] Sports represented in these studies included fly-fishing and EAAT; health conditions included TBI, PTSD, and limb amputations. Fun and enjoyment was also reported as a facilitator in Veterans with PTSD at a fly-fishing retreat.[15]

Attitude toward adaptive sports was an important motivating factor reported in 1 study.[52] Participants reported feeling a sense of belonging and an expansion on what they valued in life through adaptive sports. New experiences, such as the opportunity to travel and/or learn a new sport, was also reported as an important factor by 4 studies in Veterans.[52,69,79,103]

One study, in Veterans with PTSD, cited a reconnection to military culture as a facilitator for participating in a fly-fishing retreat. In addition, activities focused on Veteran's experiences and issues was reported to be an important characteristic of the retreat.[15]

Summary of Findings

Barriers to adaptive sports participation were similar across studies reporting on different medical conditions and different sports. Reported barriers were mainly due to physical environmental factors such as a lack of information, cost, accessibility, or transportation concerns. Personal barriers included fear of injury/pain, lack of time, and low self-esteem.

Reasons for either initiating participation or continuing participation in adaptive sports were similar. Commonly reported reasons for participation included social factors (social contacts, participation in society, interaction with others with similar disabilities) and personal beliefs

(improved health/fitness, increased self-esteem/self-efficacy, improved skill, interest in new experiences).

The majority of studies used a cross-sectional approach and collected data either through questionnaires or interviews.

SUMMARY AND DISCUSSION

SUMMARY OF EVIDENCE

Key Questions 1-3

Evidence for the effectiveness of adaptive sports ***programs*** is limited in quantity, quality, and applicability. Findings come largely from observational studies of EAAT in selected populations with PTSD (including US Veterans), MS, or CVA who agreed to participate in these programs. Many outcomes of interest were infrequently reported, including self-esteem/perceived competence, community integration/social functioning, and employment. No studies reported on health care utilization.

Evidence for the effectiveness of adaptive ***sports activity participation*** is largely from observational studies enrolling selected individuals with SCI and involving multiple sports. We found no studies exclusively enrolling individuals with PTSD, CVA, TBI, MS, ALS, or hearing loss or deafness, and few studies limited to a specific adaptive sport.

There was little evidence of harms associated with adaptive sports program participation, although few adaptive sport or populations of interest were represented in the literature. Few studies were designed to capture specific harms associated with participation.

Barriers to participation were similar across sports and population and were mainly due to physical environmental factors including lack of information, cost, accessibility, and transportation concerns. Personal barriers included fear of injury or pain, lack of time, and low self-esteem. Facilitators of participation included social factors (social contacts, participation in society, interaction with others with similar disabilities) and personal beliefs (improved health/fitness, increased self-esteem and self-efficacy, improved skills, and new experiences).

Strength of Evidence

We did not formally rate risk of bias or strength of evidence. We assessed quality characteristics of included studies and found that approximately half of the included experimental and observational studies did not provide clearly defined inclusion criteria or indicated that participants were “selected”. Many provided little demographic data to allow for a determination of the generalizability of findings. Most studies assessed outcomes using validated questionnaires or objective outcomes measures but, for questionnaires, response rates were less than 50% in 42% of the studies. Of the studies where it would be appropriate to adjust for confounding factors, there was evidence of adjustment in about 50%.

For the qualitative studies, approximately 66% reported congruity between theory and research methods. Nearly all did provide evidence of congruity between the research methods and the research questions, were considered to have adequately represented the participants, and included evidence of ethical approval of the study.

APPLICABILITY OF FINDINGS TO THE VA POPULATION

Our findings have implications for VHA and Veterans in the design, development, implementation, and assessment of adaptive sports activities and programs. There appears to be

some evidence that EAAT, in selected populations with PTSD, MS, or CVA who agreed to participate in these programs, can be beneficial. However, there is no information on resource use or the applicability to broader populations of individuals and/or program-specific details. In these populations there is little evidence of harm, though providing for broader populations (*eg*, those that are not interested in EAAT or with other medical conditions) should be done with caution and should be evaluated. Other sports activities, populations, and settings have a limited empiric base for program development and implementation. Future programs could be derived from existing programs, modified to specific populations and settings, and should undergo evaluation. Because there is general agreement that sport participation should be encouraged, future questions should examine how this can be done in populations with physical challenges that differ from those not requiring sport activity adaptation. Our findings also help categorize and describe important barriers and facilitators to participation that require additional evaluation and incorporation to ensure successful participation at acceptable costs.

LIMITATIONS

Limitations of the available literature include generally low quality of evidence (*ie*, non-randomized designs, small sample sizes, selected populations) and few studies for many of the adaptive sports and conditions of interest. Disabling conditions were often self-reported and little information was provided about severity of the condition, etiology, comorbidities, or participant demographics. Marked variation in populations, interventions, and outcomes assessment limited data pooling or even semi-quantitative assessment of effect consistency or applicability. Results from EAAT, golf, and fly-fishing programs for individuals with PTSD, MS, or history of CVA may not be generalizable to other sports and other populations. Few studies provided follow-up data to assess whether participation continued and/or whether benefits were maintained.

Participants in the studies included in our review likely had a high level of interest in sports participation (many having participated prior to injury/illness); individuals with severe illness or disability and comorbid conditions were typically excluded from the studies.

Common limitations of studies reporting harms were poor documentation and definition of adverse events. Sample sizes were generally low, and most sports activity participation studies lacked comparators. Potential harms associated with adaptive sports participation in many sports of interest or by many populations of interest are unknown.

RESEARCH GAPS/FUTURE RESEARCH

The Adaptive Sports Grant Program, facilitated and managed by NVSP&SE, may provide an opportunity for future research. The Grants Program supports entities with significant experience in managing a large-scale adaptive sports program, including programs affiliated with a National Paralympic Committee or a National Governing Body authorized to provide Paralympic sports and programs in which at least 50 persons with disabilities participate or the eligible participants reside in at least 5 different congressional districts. Federal agencies are encouraged to partner with non-federal entities to jointly create national, regional, and community-based programs that provide adaptive sports activities for disabled Veterans and members of the Armed Forces.

Our findings strongly support the need for rigorous design and outcome evaluation across a spectrum of individuals, health conditions, interventions and settings. Specific recommendations pertaining to the key questions addressed are provided below.

Key Questions 1 and 2

Future research could address benefits and harms of participation for other adaptive sports and other medical conditions. Studies could be designed to assess whether effectiveness and harms vary by severity of condition, time since disability or diagnosis, skill level of the participants, or their age, gender, or race, and participants could be followed to assess long-term outcomes. Standardized outcome measures should be used to assess a broad range of outcomes including health/wellness, daily functioning, health care utilization, and employment.

Ideally future research into benefit and harms would utilize randomized study designs with appropriate control groups. However, it has been noted that it can be difficult to recruit an adequate sample size and funding for such research may be difficult to obtain.[124]

Key Question 3

The understanding of barriers to and facilitators of participation would benefit from longitudinal studies that assessed the factors influencing regular participation over an extended period in the individual's life. Such work could be built into any new regional or national programs. The bulk of evidence reported addressed why people continued to participate in sports versus facilitators to assist individuals in initiating participation.

A gap in the evidence remains concerning the applicability and generalizability to larger populations, including a broader US population including those without an overt interest in sports participation, women, and racial and/or ethnic minorities. Several sports of interest including hand-cycling, para-triathlon, sled hockey, snowboarding, soccer, surfing, wheelchair fencing, and wheelchair lacrosse, were not represented in the literature.

CONCLUSIONS

Evidence for the effectiveness of adaptive sports programs is largely from studies of EAAT in selected populations with a history of PTSD, MS, or CVA. Thus, the strength of evidence to inform developing, implementing, making available, and evaluating the effects of adaptive sports programs or informal adaptive sports participation is low. There is insufficient evidence for other adaptive sports or populations and it is unknown whether findings from a particular sport in a particular population are generalizable. There was little evidence of harms associated with adaptive sports program participation although, again, few adaptive sports or populations of interest were represented in the literature. Barriers to and facilitators of adaptive sports participation were similar across studies reporting on a broader range of medical conditions and adaptive sports. Future research could focus on other adaptive sports and populations, other outcomes including harms, and long-term follow-up to determine if participation is sustained and if benefits are maintained.

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APPENDIX A. MEDLINE SEARCH STRATEGY

MEDLINE Search Strategy

1	(skiing or skier).mp. or exp SKIING/
2	(archery or archer).mp.
3	"Track and Field".mp. or exp "Track and Field"/
4	(athletics or "distance racing").mp.
5	(billiard$ or bocce or bocci).mp.
6	mountaineering.mp. or exp MOUNTAINEERING/
7	(mountain climb$ or hiking).mp.
8	(curling or curler).mp.
9	(bicycling or bicyclist).mp. or exp BICYCLING/
10	(hand-cycl$ or hand cycl$).mp.
11	exp Equine-Assisted Therapy/
12	(equine adj2 therapy).mp.
13	("horseback riding" or hippotherapy).mp.
14	(fishing or fly-fishing).mp.
15	(goalball or goal-ball).mp.
16	exp GOLF/
17	golf$.mp.
18	(kayak$ or canoe$).mp.
19	(triathlon or para-triathlon).mp.
20	(sailing or sailor).mp.
21	((trap$ adj2 shoo$) or (skeet$ adj2 shoo$) or sporting clay$).mp.
22	shooting sports.mp.
23	((sitting or seated) and volleyball).mp.
24	((sled or sledge) and hockey).mp.
25	snowboar$.mp.
26	power soccer.mp. or exp SOCCER/
27	(surfer or surfing or surfboard).mp.
28	scuba.mp. or exp SWIMMING/
29	table tennis.mp.
30	tennis.mp. or exp TENNIS/
31	(weightlifting or "weight lifting" or "power lifting").mp. or exp Weight Lifting/
32	(wheelchair and (basketball or fencing or lacrosse or rugby or soccer or tennis or sport$ or marathon$)).mp.
33	(sport$ adj5 (practice or participa$)).ti,ab.
34	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33
35	amyotrophic lateral sclerosis.mp. or exp Amyotrophic Lateral Sclerosis/
36	(amputation or amputee).mp. or exp Amputation/ or exp Amputation, Traumatic/

37	((limb and deficien$) or (limb and disabilit$) or (artificial and limb) or (prosthe$ and limb)).mp.
38	((hearing adj2 loss) or deaf or hearing impair$).mp. or exp Hearing Loss/
39	multiple sclerosis.mp. or exp Multiple Sclerosis/
40	exp Stress Disorders, Post-Traumatic/
41	(post-traumatic stress disorder or posttraumatic stress disorder).mp.
42	exp Spinal Cord Injuries/
43	(spinal cord injur$ or spinal cord disorder$).mp.
44	exp STROKE/
45	("cerebral vascular accident" or "cerebrovascular accident").mp.
46	traumatic brain injur$.mp. or exp Brain Injuries, Traumatic/
47	blindness.mp. or exp BLINDNESS/
48	(visua$ and (disab$ or impair$)).mp.
49	(sensory and (disab$ or impair$)).mp.
50	((mobility and disabil$) or (mobility and impair$)).mp.
51	(tetraplegi$ or quadriplegi$ or paraplegi$).mp.
52	exp Quadriplegia/ or exp Paraplegia/
53	(physical$ and (disab$ or challeng$)).mp.
54	35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 53
55	34 and 54
56	"winter sports clinic".ti,ab.
57	"summer sports clinic".ti,ab.
58	"wheelchair games".ti,ab.
59	(paralympi$ or para-olympi$ or para-sport$ or parasport$).mp.
60	exp Sports for Persons with Disabilities/
61	((adapted or adaptive) adj5 (sport$ or recreation or activit$ or exercise)).mp.
62	"special olympi$".mp.
63	(disabl$ adj3 sport$).mp.
64	(disabl$ adj2 athlet$).mp.
65	56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64
66	55 or 65
67	limit 66 to (english language and yr="1995 -Current")

APPENDIX B. CRITERIA USED IN QUALITY ASSESSMENT

EXPERIMENTAL AND OBSERVATIONAL STUDIES

(Yes/No/Unclear/Not applicable)

1. Were the criteria for inclusion in the sample clearly defined?

2. Were the study subjects and the setting described in detail?

3. Were strategies to deal with confounding factors stated?

4. Were the outcomes measured in a valid and reliable way?

5. Was there evidence of ethical approval by and appropriate body?

We also noted if outcome assessment was blinded and, for randomized trials, whether randomization and allocation were adequate.

Adapted from:

Moola S, Munn Z, Tufanaro C, et al. Chapter 7: Systematic reviews of etiology and risk. In Aromataris E, Munn Z (eds) *Joanna Briggs Institute Reviewers's Manual*. The Joanna Briggs Institute. 2017. Available from https://reviewersmanual.joannabriggs.org/ Accessed 17 December 2018.

QUALITATIVE STUDIES

1. Is there congruity between the stated philosophical perspective and the research methodology?

2. Is there congruity between the research methodology and the research questions or objectives?

3. Is there a statement locating the researcher culturally or theoretically?

4. Are participants, and their voices, adequately represented?

5. Is the research ethical according to current criteria and is there evidence of ethical approval by an appropriate body?

Adapted from:

Lockwood C, Munn Z, Porritt K. Qualitative research synthesis: methodological guidance for systematic reviewers using meta-aggregation. *Int J Evid Based Healthc.* 2015;13(3):179-187.

APPENDIX C. PEER REVIEW COMMENTS/AUTHOR RESPONSES

Question Text	Comment	Author Responses
Are the objectives, scope, and methods for this review clearly described?	Yes	Thank you.
	Yes	
	Yes	
	Yes	
	Yes	
	Yes	
	Yes	
	Yes	
Is there any indication of bias in our synthesis of the evidence?	No	Thank you.
	No	
	No	
	No	
	No	
	No	
	No	
	No	
Are there any published or unpublished studies that we may have overlooked?	Yes - Possibly, but cannot say for sure. Review seems to infer there are no studies re: dosing, yet cites dosing for SCI population.	We report that there is limited evidence on dosing because only 3 of 55 studies reported effectiveness by duration or frequency of participation.
	No	
	No	
	No	
	No	
	Yes - It would be interesting to compare the results of this systematic review to results from people without disabilities.	Our topic nominators were interested in adaptive sports for people with disabilities. This comparison would be of limited applicability and was not in our approved topic scope. We did not search for studies of sports for people without disabilities.
	No	

Question Text	Comment	Author Responses
	Yes 1) Psychological strategies of Veterans and service members who participate in organized sports. SL Peterson, JZ Laferrier, AM Koontz, H Wang, M Hannan, RA Cooper. Journal of Military, Veteran and Family Health 3 (2), 42-52, 2017. 2) Research on Physical Activity and Health among People with Disabilities: A Consensus Statement. Journal of Rehabilitation Research & Development . Apr99, Vol. 36 Issue 2, p142. 12p. Cooper, Rory A.; Quatrano, Louis A. 3) Wheelchair racing sports science: a review. RA Cooper J Rehabil Res Dev 1990;27 (3), 295-312. 4) Evaluation of a manual wheelchair interface to computer games. TJ O'Connor, RA Cooper, SG Fitzgerald, MJ Dvorznak, ML Boninger, Neurorehabilitation and Neural Repair 14 (1), 21-31. 5) The relationship between wheelchair mobility patterns and community participation among individuals with spinal cord injury. RA Cooper, E Ferretti, M Oyster, A Kelleher, R Cooper. Assistive Technology 23 (3), 177-183. 6) Sports–medicine for the disabled. The time for specialization in prosthetics and orthotics is now. RS Gailey, RA Cooper. Prosthetics and orthotics international 33 (3), 187-191. 7) Quantification of activity during wheelchair basketball and rugby at the National Veterans Wheelchair Games: A pilot study. ML Sporner, GG Grindle, A Kelleher, EE Teodorski, R Cooper, RA Cooper. Prosthetics and orthotics international 33 (3), 210-217, 2009. 8) Sports and Recreation for People with Spinal Cord Injuries. I Rice, RA Cooper, R Cooper, A Kelleher, A Boyles. Spinal Cord Injuries: Management and Rehabilitation, 455-47, 2009. 9) The Gamecycle Exercise System: Comparison With Standard Ergometry. SG Fitzgerald, RA Cooper, T Thorman, R Cooper, SF Guo, ML Boninger. The journal of spinal cord medicine 27 (5), 453-459, 2004. 10) An investigation of the exercise capacity of the wheelchair sports USA team. RA Cooper, TJ O'Connor, RN Robertson, WE Langbein, FD Baldini. Assistive Technology 11 (1), 34-42, 1999.	Thank you for the suggested references. We have reviewed each of them for eligibility for inclusion. Only reference #12: Boninger was eligible for inclusion (KQ2). We also added reference #6 into the discussion under Limitations or Research Gaps 1) The focus of this study is on psychological skills/strategies used during competition. Longer participation in sports was associated with improved psychological skills but those skills were not an outcome of interest for our review. 2) The focus of this consensus statement is on physical activity rather than adaptive sport. 3) This paper is a narrative review published outside of our search dates of 1995 to the present. 4) This study reports physiological outcomes during exercise training which are not outcomes of interest for this review. 5) This study does not quantify adaptive sports participation. 6) This paper is now incorporated in the discussion. 7) This study reports on distance traveled and other measures of activity during wheelchair basketball and wheelchair rugby. These were not outcomes of interest for this review. 8) This book chapter/narrative is focused on training techniques rather than outcomes. 9) This study focused on physiological outcomes (oxygen consumption) and perceived exertion which were not outcomes of interest for this review. 10) This study focused on physiological outcomes (metabolic responses) which were not outcomes of interest for this review. 11) Please see #2 above.

Question Text	Comment	Author Responses
	11) Research on physical activity and health among people with disabilities: a consensus statement. RA Cooper, LA Quatrano. Journal of Rehabilitation Research & Development 36 (2), 1999. 12) UPPER LIMB NERVE ENTRAPMENTS IN ELITE WHEELCHAIR RACERS, ML Boninger, RN Robertson, M Wolff, RA Cooper. American journal of physical medicine & rehabilitation 75 (3), 170-176, 1996. 13) CARPAL TUNNEL SYNDROME IN PARALYMPIC WEIGHT LIFTERS. ML Boninger, M Wolff, RA Cooper, RN Robertson. American Journal of Physical Medicine & Rehabilitation 74 (2), 173, 1995. 14) Maximal exercise response of paraplegic wheelchair road racers. RA Cooper, SM Horvath, JF Bedi, DM Drechsler-Parks, RE Williams. Spinal Cord 30 (8), 573, 1992. 15) Training practices of athletes who participated in the national wheelchair athletic association training camps. KT Watanabe, RA Cooper, AJ Vosse, FD Baldini, RN Robertson. Adapted Physical Activity Quarterly 9 (3), 249-260, 1992.	12) We added this study to the results for Key Question #2. 13) This citation is for an abstract and therefore would not be eligible for inclusion in the review. 14) This study focused on physiological outcomes (heart rate, ventilation, oxygen consumption) which were not outcomes of interest for this review. The 1990 study is also outside of our search range. 15) This is a survey of training practices including exercise, diet, and mental preparation. It does not report outcomes of interst for review. The 1992 study is also outside of our search range.
Additional suggestions or comments can be provided below. If applicable, please indicate the page and line numbers from the draft report.	Text of review appears to have been written by different writers. Some sections are very detailed (e.g., citing study methodology, analysis, etc), while other sections of the report (citing studies) are not as thorough. *Specific Comments* Page 1, Lines 53-58: acronyms provided for included diagnoses in lines 29-33 on same page, therefore recommend only using only the acronyms moving forward Page 2, Lines 13-16 and 20-24: same comment regarding acronym use Page 3, Lines 58-59: the definitions for “program” used in this report are not consistent with the typical use of that terminology.Strongly recommend changing the terminology for the groupings. Page 4, Lines 43-48: Again strongly recommend changing the grouping terminology from “program” and “non-program” because the current definitions are not consistent with definitions in the field Page 5, Lines 5-7: The first sentence is awkward, and recommend a revision to ensure the intended message is clear	We reviewed and edited for better consistencyconsistency. Page 1 and Page 2: We replaced the diagnoses with acronyms throughout the document except where the diagnoses are part of a Key Question. Pages 3 and 4: This was discussed on several conference calls with our partners and TEP. There was no disagreement with our use of these terms. Suggested terms such as “cross-sectional” or “longitudinal” are generally reserved as methodologic study descriptors not an intervention characteristic. Furthermore, this does not accurately classify the differentiation. We now provide our definition of “program” and changed “non-program to “sports activity participation”. These studies do not provide a formal description of any “program” involved with the sports participation (a key component of our description).

Question Text	Comment	Author Responses
	Page 5, Line 7: spell out “mental health” (versus MH) for consistency with remainder of document ** continue recommendation for all instances of “MH” in the document ** Page 5, Line 12: replace “stroke” with “CVA” for consistency with Key Questions terminology ** continue recommendation for all instances of “stroke” in the document ** Page 5, Line 15: “…not associated with different aspects…” seems to be missing something.Potentially add “improvements in” after with, if appropriate for the intended message Page 5: Having the Outcomes by Sports adjacent to the Outcomes by Population, differences/contradictions in the summaries are much more apparent.Recommend breaking up the sections (e.g. fully address KQ1 “by sport” and then fully address KQ2 “by population”) Page 5, Line 48: Suggest change “mixed for the balance outcome” to “mixed regarding influence on balance”, if appropriate for the intended message Page 5, Lines 55-56: Unsure if final sentence adds anything.More appropriate to highlight if a study does have a significant number of Veterans included in the population Page 6, Lines 12-13: Suggest change “little information about” to “little support for”, if appropriate for the intended message Page 7, Lines 23-26: I assume that adverse events from all studies considered for KQ1 were also considered for review in KQ2, so I would think that should be reflected here. I believe any adverse events and reasons for participant withdrawals from these studies should be considered when assessing harm, not only those studies specifically aimed at assessing harm. Page 7, Line 38: number of studies (assuming 1) is missing before “was a narrative analysis” Page 8, Lines 15-60: the Discussion seems to be more a repetition of the Results. Understand if this type of work is not comparing to other works, but maybe more of a take home, or re-frame the results to not include commentary (save that for the discussion). Page 8, Lines 33-36: Example of a statement that is really a result, and not a discussion point	Page 5 Lines 5-7: sentence edited Page 5 Line 7: replaced MH with mental health throughout Page 5 Line 12: see above re acronyms Page 5 Line 15: added “changes in” Page 5 Our partners were interested in outcomes by sport and by population. Doing so does mean there is overlap of studies. Page 5 Line 48: Thank you for the suggestion. Page 5 Lines 55-56: Thank you – sentence deleted. Page 7 Lines 12-13: We believe the statement is correct as is. Page 7 Lines 23-26: Adverse events from all studies in KQ1 were included in KQ2. Page 7 Line 38: corrected – 1 narrative analysis Page 8 Lines 15-60 We revised the discussion to provide more take home messages including suggestions for using these findings to design, develop, make available, and evaluate future adaptive sports programs and participation for Veterans in and outside of VHA. Page 8 Lines 40-42: We added more detail about harms to the Results section the Executive Summary. As noted above, adverse events resulting in withdrawal from a study identified for KQ1 were included under KQ2.

Question Text	Comment	Author Responses
	Page 8, Lines 40-42: There is evidence referenced on 41- 44 that describe potential harms that can occur when participating in adaptive sports. These results should be included in the summary. Of course, identifying harms does not imply that people should not participate in sports, as it is understood that anyone participating in a sport is more likely to incur an injury, most often musculoskeletal, than someone who is not participating in a sport. However, it is important to identify the most common injuries so that providers involved with these events can help mitigate the risk through things like proper training and equipment. Suggest also discussing adverse events and reasons for participant withdrawals listed in other studies as well.	
	Page 9, Lines 30-31: Sentence "no studies provided outcomes data for…" is confusing, and may not add much value beyond what is already written, so suggest removing	Page 9 Lines 30-31: We believe this sentence is a lead-in to our statement about generalizability.
	Page 9, Lines 31-34: if listing populations where research exists, suggest adding "SCI" to the list of conditions (PTSD, multiple sclerosis, stroke…) for completeness since 20 studies reviewed in this population for KQ1.	Page 9 Lines 31-34: This sentence refers specifically to the populations studied in the sports listed.
	Page 9, Line 33: replace "multiple sclerosis" with "MS" for consistency with Key Questions terminology	Page 9 Line 33: see above comment re acronyms
	** continue recommendation for all instances of "multiple sclerosis" in the document. Same comment for instance of "stroke" on this line, but comment to correct throughout listed above **	Page 9 Lines 44-45: We revised this sentence – our statement was about the participants in the included studies.
	Page 9, Lines 44-45: recommend removing statements regarding "elite athletes" since this literature was not reviewed and so any comments in this section are unsupported commentary	Page 9 Lines 45-56: We revised this sentence; we did not exclude studies of individuals with severe illness or disability – this statement is referring to the exclusion criteria of the primary studies we reviewed.
	Page 9, Lines 45-56: unsure of why "individuals with severe illness or disability and comorbid conditions" were excluded from the analysis. This "exclusion" was not listed in the exclusion criteria, and the information for these patients may be very relevant because they may be participating in adaptive sports events hosted by the VA NVSP&SE. Also, a definition should be provided for the criteria used when screening "severe illness or disability" because some individuals may classify SCI into this category.	Pages 10-11: The Gaps/Future Research section was revised to focus on research gaps.

Question Text	Comment	Author Responses
	Pages 10-11, Lines 34-27: The Gaps/Future Research section includes many additional comments about the Limitations of the studies included, and did not focus primarily on identifying the Gaps. For example, the initial paragraph for KQ3 is listing limitations of the studies that could instead be included/added to the summary in the Limitations section on Page 9. Recommend reshaping this section to provide clear gaps so that others can help focus future efforts in these areas, improving the overall quality of the body of evidence available. Page 11, Lines 32-33: include SCI in diagnoses list with evidence Page 11, Lines 36-37: revise conclusion on harms to more accurately reflect the literature reviewed Page 14, Lines 23-28: only utilize acronyms for conditions listed in KQ1, because already defined on Page 13, Lines 42-46 Page 14, Lines 39-42: only utilize acronyms for conditions listed in KQ2, because already defined on Page 13, Lines 42-46 Page 14, Lines 47-51: only utilize acronyms for conditions listed in KQ3, because already defined on Page 13, Lines 42-46 Page 14, Line 53: include acronym "(VHA)" after "Veterans Health Administration" because it is used later in the paragraph (Line 58) Page 14, Line 55: can use acronym "NVSP&SE" in place of "National Veterans Sports Programs and Special Events" because previously defined on Page 13, Line 20 Page 14, Line 58: change "VHA's national programs for rehabilitation" to "VHA's rehabilitation programs that incorporate adaptive sports within their treatment plan" Page 14, Line 58-59: change "the Disabled Veterans Adaptive Sports Programs" to "the national programs hosted by the NVSP&SE" Page 18, Line 13: articles for KQ2 should include all of those reviewed in KQ1 because participant who withdrew or experienced an adverse event should be considered to determine if due or related to a potential harm. Page 18, Lines 13-16: remove final statement listed studies on "elite athletes" and list "studies conducted on elite athletes" to the exclusion criteria.If it is not appropriate to include as an exclusion	Page 11 Lines 32-33: see above re sports and populations in those sports Page 11 Lines 36-67: We believe this sentence accurately reflects the literature reviewed. Page 14 Lines 23-28, 39-42, 47-51: We chose to leave the acronyms when they are part of a Key Question. Page 14 Line 53: VHA added Page 14 Line 55: replaced with NVSP&SE Page 14 Line 58: change made Page 14 Line 58-59: change made Page 18 Line 13: KQ1 studies reporting adverse events are included in KQ2. Page 18 Lines 13-16: This sentence has been revised - studies of elite athletes were not excluded but were not included in our analyses; we provide reference citations for readers interested in those studies. Page 19: see above Page 20: Lines 34-36: see above response re: program and non-program

Question Text	Comment	Author Responses
	criterion, then it leads to the question of why this data was not included in the summaries. Page 19: Move excluded studies for “elite athletes” to a box of excluded studies Page 20, Lines 34-36: Again strongly recommend changing the grouping terminology from “program” and “non-program” because the current definitions are not consistent with definitions in the field ** continue recommendation for new terminology for remainder of the KQ1 section ** Page 20, Line 56-57: Suggest changing “Medical conditions and adaptive sports included” to “Medical conditions by adaptive sports included” Page 21, Table 2: Suggest including all diagnoses of interest in the analysis at the top of the table to clearly illustrate diagnoses where data is lacking. Also suggest using acronyms for all conditions for consistency with KQ Page 21, Table 2: Suggest breaking out the “Multiple” medical condition. For example, if the single study included MS and SCI, then both MS and SCI would have it indicated in the column.Suggestion would result in the total tally for the table to exceed the number of studies identified, however for a reader looking for studies in MS, using this hypothetical example, he/she would know there are 5 studies on EAAT, 3 on hiking and climbing, and 1 that included multiple sports. Page 21, Table 3: Suggest indicating any categories of age covered for all studies. For example, assuming age is reported in all studies, so the 25th study not currently represented within any of the categories for the Age characteristic was not included because the authors included an age range that crossed over multiple categories listed in the table. If this assumption is correct, then recommend a “1” be included for all age ranges. This addition may result, in this hypothetical example, to have >50 years and 25-49 years both having 13 studies indicated, and maybe <25 now having 1, exceeding the overall number of studies, but it would be clear for a reader to know how many studies are available that assessed individuals in the age range of his/her interest.Same comment for all 3 characteristics, when the data is present in the study.	Page 20 Line 56-57: change made Page 21 Table 2: Thank you for the suggestion; a column showing all the diagnoses with no data was added to Table 2 and Table 6. Page 21 Table 2: The studies with either multiple medical conditions or multiple sports did not report results by condition or sport. Page 21 Table 3: We clarified on the table that for Age and Time from Injury or Diagnosis, the counts for each range are the number of studies with a mean or median value for Age or Time that falls in the categories listed; the studies may or may not have reported a range; one study did not report a mean or median age; 11 studies did not report on time from injury or diagnosis Page 21 Lines 43-52: In the final report, all references have been replaced with superscript numbers. Page 22 Lines 43-45: This statement has been reworded.

Question Text	Comment	Author Responses
	Page 21, Lines 43-52: a suggestion for citation style would be to either list the references in alphabetical or chronological order ** continue recommendation for all instances of referenced literature **	
	Page 22, Lines 43-45: confused by the statement “no study reported…” so suggest rewording to “No impact on pain or overall health was reported for individuals with…” if this wording appropriately captures what was reported in the literature referenced	Page 22 Lines 48-49: We chose to leave statements about possible worsening of the KQ1 outcomes in the KQ1 results (as noted on the arrow tables, no worsening was reported).
	Page 22, Lines 48-49: final sentence “There were no reports of worsening…” more appropriate for KQ2 than KQ1.	Page 22 Line 55: Since many of the studies are observational studies, we believe that “associated with (or not)” is the appropriate terminology.
	Page 22, Line 55: terminology “program participation was not associated with” is unclear, unless all referenced studies completed correlation analyses. Potentially phrase could be reworded as “program participation did not influence” if this appropriately reflects what was reported in the literature	Page 23 Line 7: open parenthesis replaced with citation number Page 23 Line 7: statement revised
	Page 23, Line 7: add space between “balance” and the open parenthesis	Page 23 Line 39: parenthesis removed after replacement of citations with superscript numbers
	Page 23, Line 7: add the measure after “found no significant difference”. If appropriate for the referenced literature, could revise to “found no significant difference in balance”.Also see note below (Page 23, Lines 38-58)	Page 23 Lines 38-58: We now refer the reader to the Appendices for more detail about the individual studies and outcomes data.
	Page 23, Line 39: add a closed parenthesis after “Malinowski 2017”	
	Page 23, Lines 38-58: this section is an excellent summary of the literature reviewed. It includes details of the studies, to include the measures assessed in the studies and the change that occurred (to include mean scores and p-values). Potentially this detail is greater than what was intended for this type of review, but when a section such as this section is adjacent to other sections, such as Lines 5-12 referencing 3 studies on Golf, at least one of which had significant results, these other sections seem to be lacking. As a reader, preference would be to have all sections more like the referenced PTSD section because it includes very useful information.	Page 31 Table 6: see comments for Table 2 above
	Page 31, Table 6: ** Same suggestions as for Table 2 on Page 21** Suggest including all diagnoses of interest in the analysis at the top of the table to clearly illustrate diagnoses where data is	Page 31 Table 6: see comments for Table 2 above

Question Text	Comment	Author Responses
	lacking. Also suggest using acronyms for all conditions for consistency with KQ Page 31, Table 6: ** Same suggestions as for Table 2 on Page 21** Suggest breaking out the “Multiple” medical condition. Page 32, Table 7: ** Same suggestions as for Table 3 on Page 21** Suggest indicating any categories/ranges covered within the 30 studies, for all 3 characteristics. Page 32, Line 50-51: based on Table 8, there were 10 studies that addressed these sports. Other sections have provided a valuable summary of the articles, even when it is limited to a single study or two. It would be appreciated by the reader if these 10 studies could be summarized similarly, especially because Table 8 also indicates there were significant results in multiple of these studies. Pages 32, 35-36: Similar comment to Page 23, Lines 38-58 regarding depth and consistency of information provided is recommended for the sections included across these pages Page 39, Lines 6-30: Another example where the first paragraph references 3 studies and the second references 1, however the paragraph on the single study includes many additional details. The difference is made more evident because they are adjacent to each other, but as a reader the additional detail included in the second paragraph is appreciated. Page 39, Lines 39-40: This sentence highlights the difference in terminology used in the field, where the three events listed in this sentence would be considered adaptive sports programs, yet the study is referenced as a “non-program” study, likely because the approach was cross-sectional. A change in terminology would clarify any confusion. Page 39, Line 43: remove acronym “(SER)” if not used again Page 40, Line 14: add a comma after “SCI” Page 41, Line 15: suggest all articles included in KQ1 be considered for KQ2, regardless if the primary aim/objective of the study was to assess harm. Any/all withdrawals or adverse events should be identified and considered to potentially contribute to a better understanding of potential risks/harms associated with participation in adaptive sporting events. Page 41, Lines 21-23: Do not agree that the events that occurred by the participants with MS should have been excluded from this	Page 32 Table 7: see comments for Table 3 above Page 32 Lines 50-51, 35-36, Lines 6-30: As noted above, we now refer the reader to the Appendices for more details about the individual studies and outcomes data. Page 39 Lines 39-40 Please see comments above regarding program and non-program terminology. Page 39 Line 43: acronym removed Page 40 Line 14: added Page 41 Line 15: All articles in KQ1 were included in KQ2 if they reported adverse events. Page 41 Lines 21-23: We disagree with the reviewer’s request to add this information as the findings would not address KQ2: What are the harms of participation in individuals with MS? We stated that the findings were excluded because participants in the treatment and comparator groups (if present) had exacerbations and neurological worsening during study

Question Text	Comment	Author Responses
	analysis. These events may provide very valuable information to assist providers involved with these types of activities to identify how to best approach and/or modify the activity to ensure these individuals are able to safely and effectively participate in these types of activities.Strongly agree that this information needs to be added to this section of the report. Page 41, Lines 37-41: Suggest removing the following sentence: "The large number of injuries…" Conservative approach would be to not question an investigator's determination of adverse events because they may be warranted, and/or the determination may be based on direction the investigator received from the review board overseeing the research. Page 42, Line 47-49: Suggest moving (You 2016) citation up to after first sentence. Page 42, Line 50: Remove "et al." from citation for consistency with other citations Page 44, Lines 12-15: the previous few pages had a great summary of the available literature that illustrates some potential harms/risks of participation in adaptive sports.This summary does not accurately reflect this review and should be updated. Page 46, Line 23: change "twenty-five" to "25" to be consistent with remainder of the document. Style has been to list numerically whenever the number is not the beginning of the sentence. Page 46, Line 45: change "twenty-six" to "26" (for reasons previously indicated). Page 46, Line 46: "focused mainly on amputees, SCI, or multiple diagnoses reported that" should be "reported mainly on individuals with limb amputations, SCI, or multiple diagnoses found that" Page 46, Line 54: "amputees" should be replaced with "individuals with limb amputations" Page 48, Line 7: "so they could participate" should likely be change to "so they chose not to participate" but please confirm wording consistent with referenced findings. Page 48, Line 18: change "twenty-five" to "25" (for reasons previously indicated).	participation; these events were excluded from our analysis as they could not be attributed solely to adaptive sports participation. Page 41 Lines 37-41: sentence modified Page 42 Line 47-49: superscript citation number follows first sentence Page 42 Line 50: citation in parentheses removed Page 44 Lines 12-15: While we agree with our original summary wording we changed to say "infrequent and generally not serious" based on the authors specific statements or the nature of the injury ("minor" "fatigue but not "excessive fatigue").Page 46 Lines 23 and 45: words replaced with numerals throughout for consistency of style Page 46 Lines 46 and 54: changed as suggested Page 48 Line 7: sentence was modified Page 48 Line 18: replaced (see comment above) Page 48 Lines 18-19: sentence was modified Page 48 Line 23: replaced (see comment above) Page 48 Line 52: replaced throughout the document

Question Text	Comment	Author Responses
	Page 48, Lines 18-19: “Eleven studies also reported” should be “Of these, 11 studies reported” if these 11 are include in the initially referenced 23 studies. Page 48, Line 23: change “twelve” to “12” (for reasons previously indicated). Page 48, Line 52: “amputees” should be replaced with “individuals with limb amputations” Page 49, Line 14: “l” missing at the end of “general” Page 49, Lines 14-16: Move citation to the end of the sentence (and cite as “Chard 2017”) to be consistent with formatting utilized throughout other sections. Page 49, Line 35: “TBI” previously defined on only need to list “TBI” in this instance Page 49, Line 36: confirm studies including individuals with “tetraplegia”, “quadriplegia”, and “paralysis” were not the result of a SCI, or else these studies should be referenced above in the same paragraph (lines 27-28) Page 49, Lines 22-39: Did these studies indicate that the health conditions were facilitators or motivators of participation in adaptive sports. The paragraph completely lays out the studies that included these diagnoses, but does not as clearly indicate if these conditions were found to be facilitators or motivators. Page 51, Lines 8-10: Change in-sentence reference to “Kars et al.” and move citation to the end of the sentence to be consistent with formatting utilized throughout other sections. Page 51, Line 9: “lower limb amputees” should be replaced with “individuals with lower limb amputations” Page 51, Lines 9: Change in-sentence reference to “Bragaru et al.” Page 51, Line 10: “prosthetics” should be changed to “prostheses” or “prosthetic devices” Page 51, Line 11: “prosthetics” should be changed to “prostheses” or “prosthetic devices” Page 52, Line 8: add “limb” in front of “amputation” Page 52, Line 12: “amputees” should be replaced with “individuals with limb amputations” Page 52, Line 43: add “limb” in front of “amputation” Page 52, Line 53: add “limb” in front of “amputation” Page 52, Line 58: add “limb” in front of “amputation”	Page 49 Line 14: corrected Page 49 Lines 14-16: sentence revised with citation at the end Page 49 Line 35: replaced with abbreviation Page 49 Line 36: We used the language provided in the original studies which did not specify if the tetraplegia, quadriplegia, and paralysis resulted from a SCI. Page 49 Lines 22-39: Studies did not indicate whether health conditions influenced participation in adaptive sports; we added a sentence to clarify this point. Page 51 Lines 8-10: sentence modified Page 51 Line 9: see correction above Page 51 Line 9: sentence corrected Page 51 Lines 10 and 11: changed to “prosthetic devices” Page 52 Line 8 and others listed below: “Limb” added in front of “amputation” throughout the document. Page 53 Lines 11 and 17 (below): As noted above, we used the language provided in the original studies which did not specify if the tetraplegia, quadriplegia, and paralysis resulted from a SCI.

Question Text	Comment	Author Responses
	Page 53, Line 5: add “limb” in front of “amputation” (and change “an” to “a”) Page 53, Line 11: confirm studies including individuals with “paraplegia” and “tetraplegia” were not the result of a SCI Page 53, Line 11: add “limb” in front of “amputation” Page 53, Line 17: confirm studies including individuals with “paraplegia” were not the result of a SCI Page 53, Line 34: suggest changing “extremity” to “limb” for consistency Page 53, Line 40: add “limb” in front of “amputation” Page 53, Line 48: add “limb” in front of “amputation” Page 54, Line 10: add “limb” in front of “amputation” Page 54, Line 42: change period at the end of the citation to a closed parenthesis Page 54, Line 45: add “limb” in front of “amputation” Page 54, Line 47: add “limb” in front of “amputation” Page 54, Lines 53-54: change “among tetraplegics and amputees” to “among Veterans with tetraplegia or limb amputation” (suggest list as “Veterans with SCI” if cause of tetraplegia was SCI). Page 55, Line 18: add “limb” in front of “amputation” Page 56, Line 10: same concern regarding terminology “program” and “non-program” indicated above Page 56, Lines 21-22: final sentence “there were no reports…” related to KQ2 more than KQ1 Page 56, Line 25: same concern regarding terminology “program” and “non-program” indicated above Page 56, Line 26-29: “spinal cord injury” should be “SCI” and “amyotrophic lateral sclerosis” should be “ALS” for consistency Page 56, Line 26-30: There were many studies reviewed for participation in sports of individuals with SCI, and these findings should be better captured here Page 56, Lines 34-36: KQ2 summary should be re-written as recommended above Page 57, Lines 31-32: Sentence “No studies provided outcomes data for many adaptive sports…” doesn’t seem accurate since studies reporting on multiple sports were included in this report, so the meaning of this sentence may not be clear, and therefore it is recommended to remove it.	Page 53 Line 34: changed as suggested Page 54 Line 42: corrected with change to superscript citations Page 54 Lines 53-54: As noted, we used the language provided in the original studies. Page 56 Line 10: see above regarding terminology Page 56 Lines 21-22: see previous comment re “worsening” Page 56 Line 25: see above regarding terminology Page 56 Lines 26-29: abbreviations are now used throughout the document except in the Key Questions (as noted above) Page 56 Lines 26-30: section modified Page 56 Lines 34-36: More text was added to the Results summary but we believe this is an accurate overall summary for KQ2 Page 57 Lines 31-32: As noted for the Executive Summary, we believe this sentence is appropriate; studies reporting on multiple sports did not report result by sport. Page 57 Line 38: “*ie*” has been added Page 57 Lines 45-47: This text has been modified as in the Executive Summary.

Question Text	Comment	Author Responses
	Page 57, Line 38: add “based on” inside of the parentheses – “(based on age, gender..) Page 57, Lines 45-47: remove these lines as indicated above (commented change for Page 9, Lines 44-45 and Page 9, Lines 45-56) Page 57, Lines 52-53: “Most of the evidence…” is not a statement of a limitation. The limitation would be that potential harms to other diagnoses of interest were not covered as thoroughly as potential harms for the SCI and MS populations Page 57, Line 53: Change “spinal cord injuries” to “SCI” for consistency Page 57, Line 57-60: update terminology for “program” and “non-program” and update number of studies that can be considered for addressing KQ2 (as suggested in comment for Page 41, Line 15) Page 58, Line 5: change “1” to “one” for consistency with remainder of document Page 58, Lines 43-50: Address “program” and “non-program” terminology Page 59: Lines 5-16: again this section is great information, but it may be better to include it in the Limitations section versus the Gaps/Future Research section Page 59, Lines 41-42: revise conclusion on harms to more accurately reflect the literature reviewed	Page 57 Lines 52-52: sentence modified Page 57 Line 53: see above re acronyms Page 57 Lines 57-60: see above regarding terminology Page 58 Line 5: the current ESP style is to use the numeral “1” in most cases and the report has been corrected for consistency Page 58 Lines 43-50: see above regarding terminology Page 59 Lines 5-16: Thank you for the suggestion; we have elected to leave it as is. Page 59 Lines 41-42: As noted above, we believe this sentence accurately reflects the literature reviewed.
	none	Thank you.
	The manuscript is very easy to read. However, going back and forth for on the Key Questions posed a problem of trying to keep the subtopics in check for this reviewer. Only comment I have is that if after the review of the articles, can we compare Veterans only articles vs general population articles and make any inference or conclusions. I do not have anything else to add as a reviewer.	Thank you. We reviewed the organization of the report. There is not sufficient evidence to make inference or conclusions about adaptive sports for Veterans vs. the general population.
	1. Overall the report reads well - flows nicely and is easy to follow. 2. I have made some comments directly on the document - a few items that stand out; first of all, in the studies, do Veterans	1) Thank you. 2) Veterans typically reported other diagnoses; if one diagnosis (*eg,* PTSD) was predominant, we identified the study as a study of that diagnosis.

Question Text	Comment	Author Responses
	identify only as a person with PTSD, or are other diagnosis's listed? 3. Exclusion criteria is not clear in regards to physical activity. 4. Double check formatting and use of acronyms, placement of periods and spaces. 5. Although it is great to see author's names and identify key research, I am wondering if AMA format would read better - it is "clunky" to read in some areas. *Specific comments from document* Page 5 the title should be changed from Associate Chair to Graduate Coordinator Page 9 1) This sentence reads awkward - do we want to say "harms" or concerns. 2) Can we combine spinal cord disorder and spinal cord injury? I am assuming "no", but thought I would ask. Page 10 should this be separated into two questions - facilitators one question, barriers the second question. Page 11 1) Different font on headings. 2) Were "physical activity" only studies excluded as well? Page 12 1) do we know the range of years? from xxxx to 2019? 2) GREAT clarification 3) wondering if question 1 should be restated here? Page 14 1) Interesting finding - this shows we all have plenty of work ahead of us! :-) 2) Interesting... Page 17 It seems that this limitation of generalizability is common across sport studies. Page 24 I am assuming how this reads that exercise/physical activity studies were included? Page 28 1) Is there a reason this is all in large caps? The format seems as if you are "yelling" at the reader. 2) Was the only identified diagnosis PTSD? Page 44 were identified Page 48 This reads well - minimal comments or suggestions. Page 53 A one sentence brief definition of the ICF will be helpful here, in addition, these are "domains" of the ICF, not categories. Page 54 Just curious why only the first author is listed? Page 55, Figure 2 This is GREAT!	3) We added that studies involving physical activity must include a “sport” component. 4) We edited and attempted to identify and correct any formatting/grammatical inconsistencies throughout the document. 5) Author’s names appeared in the peer review version; for the final version, the citations appear as superscripted numbers. Page 5: corrected Page 9 1) Our interest was in harms – injuries, etc. during participation. 2) These were considered separate conditions. Page 10. In the reporting of findings for Key Quesiton3, we address barriers and facilitators separately. Page 11 1) All fonts checked for consistency with ESP style. 2) We required that there be a “sport” component (one of the sports of interest). Page 12: 1) Added the range of years (also reported in the Methods); 2) Thank you; 3) Given the length of the Key Questions, we chose not to add the question here. Page 14: 1), 2) Agree! Page 17: We agree but the issue is probably even greater here when the variability of condition/severity and necessary adaptations may make big differences. Page 24: Yes – as noted above there had to be a sport component. Page 28: 1) Thank you for the feedback; 2) See comment above re diagnoses Page 44: We believe “reported” is correct. Page 48: Thank you Page 53: Thank you for the suggestion. We added a brief sentence on the ICF model and replaced the word ‘categories’ with the word ‘domains’. Page 54: The author names are removed and citations are in superscript format in the final report. Page 55: Thank you

Question Text	Comment	Author Responses
	Page 56 I am wondering if AMA format would be easier to read? I am torn, because it's great to see who the authors are, and recognize key studies, yet, it is "clunky" to read. Page 58 Figure 3 This is GREAT! Page 59 I think the list of citations would be better reported in a table. Page 64 I think one of the limitations not mentioned is that we really don't know the disabling conditions...it's self-reported and typically there is more than one disability present. Page 65 Few studies with standardized assessments measuring clinical outcomes. Page 66 Possibly examine the different domains of the ICF and how this impacts engagement in sport (?) May not be necessary - just a thought. Page 67 EAAT - check when using acronyms throughout the document.	Page 56: The final report is in AMA format. Page 58: Thank you Page 59: The citations have been replaced with superscript numbers. Pages 64 and 65: Thank you – we included these suggestions in the limitations section. Page 66 Thank you for your comment. Although we used the ICF framework to conceptualize reported barriers, motivators, and facilitators the studies themselves did not necessarily report this way. No studies examined how the ICF domains impacted participation, therefore we are unable to comment. Page 67: Thank you – we now use this acronym throughout and have checked other acronyms for consistency.
	Review of “ADAPTIVE SPORTS FOR DISABLED VETERANS” The systematic review aims to answer three key questions. The authors provide adequate information about how they chose the articles that were reviewed, but not necessarily why the articles were chosen. I have a number of issues with the current version. Major Comments. 1. There is no justification presented for the choices made to include/exclude studies or activities. Justification is needed for the inclusion/exclusion criteria, for why elite athletes weren’t included, for why human performance laboratory studies were excluded, for why and how the outcomes were put into the 7 categories that you’ve identified, and for why the listed activities were chosen. Are the different activities important to the overall conclusions of this review? Why are they sometimes distinguished and sometimes combined? How and why were the specific activities chosen? 2. It is not apparent that the authors answered the questions that were presented. The questions should be answered and clearly supported with quantitative evidence collected in the review.	We developed a protocol for the review (including the key questions, sports, medical conditions, and inclusion/exclusion criteria) to address the interests of our Operational Partners. We focused on study design that might provide some level of certainty though given the paucity of data we included studies at much higher ROB than typically included in evidence reports to determine intervention effectiveness. 1) As noted above, the review criteria were developed to meet the information needs of our Partners. Studies of elite athletes would be of limited applicability to the overall Veteran population. Laboratory studies would yield outcomes that are not patient-centered or broadly applicable. The categories of outcomes provided a logical grouping of the outcomes of interest to allow us to speak more broadly about the studies (vs single studies reporting different measures of the same outcome). Our Partners developed the list of activities and medical conditions. There was interest in outcomes by activities and by medical conditions and therefore activities were sometimes reported individually and sometimes combined.

Question Text	Comment	Author Responses
	3. The current version is repetitive and reads like a sometimes-unrelated list. The authors should also consider reorganizing the information to have a better flow. The way in which the information is presented is hard to follow. Each paragraph needs a topic sentence or summary sentence so that the main point of the paragraph is understood and the paragraphs are linked. Right now, it seems like each paragraph is a reiteration of the list of results. Consider reorganizing the results to support the main points of the review. 4. What is the big overall result of this analysis, why is it important, and how will it change adaptive sports in the future? Please provide a summary of what the findings mean. Are there enough studies? Why are the experimental designs important? If the study quality is poor, are these valid results to report? Why are the results important? 5. There are no comparisons of this systematic review with other reviews. For example, how does the incidence of injury compare to people without a disability? How does quality of life compare? The review would benefit from context and references to other studies. Are the barriers to participation different for people with disabilities compared to without? How might we address similarities or differences to promote participation? Additional comments Define effectiveness	2) We disagree that we did not answer the posed key questions. Other reviewers did not raise this concern. It is true that the evidence available provides little high quality or applicable information that can allow stakeholders to have confidence that implementation in VHA will result in similar findings. We discussed these limitations at great length. We also do not believe that formal quantitative analyses is appropriate or would be useful in this situation e given the heterogeneity and paucity of data on a given activity or condition.Furthermore, the methodological quality as assess by risk of bias and clinical applicability for included studies was very low. In many instances we resorted to small, single, observational studies of unique populations, with unique interventions and settings. We did this because we attempted to provide some level of information on this important topic despite the paucity of data for the key questions. 3) We have done some reorganization. We attempted to provide results stratified by intervention, condition, and program and participation. There was little information according to sex or race or comorbidities. We also provide information when available in Veterans. As noted, there was interest in outcomes by sport and by conditions which, by design, requires some repetition. 4) We believe such a comparison would be of little value and potentially hazardous. Ideally, we would have been able to synthesize and summarize but with the available data, our options were limited. There are few studies (or no studies) for many of the sports and medical conditions. Experimental design is important for credibility, certainty of information, risk of bias and applicability of findings. Based on discussion with our Partners we erred on including a range of study designs with varying quality with the caveat that they are high risk of bias, low applicability, and very unique 5) These would be incredibly hard comparisons to make and likely flawed. We did identify and include a few small studies that included groups of individuals with and without disabilities (*eg*, sighted and non-sighted soccer players).

Question Text	Comment	Author Responses
	P4 Line 10. Are you referring to the community level and up? How are you defining the community level? P5-6. starting at line 36. What are these being compared to? Improved compared to what? P7. A take-home message or topic sentences would help convey the primary results for each question. P7 line 38. You're missing a number here in front of "was a narrative analysis" P8 Line 16. Define quantity, quality, and applicability. P8 Line 41. Quantify what you mean by "few" P9 Lines 24-25. How was "quality" assessed? What do you mean by "small in size"? Please quantify these statements throughout. P10. What should be done by future studies and why? P10 Line 69. Define "helpful" P11 Line 12. What are the important barriers that may not be identified? Why is this important? P22. Why are these results important? P22. Lines 42-45. What does this refer to? P24 Lines 3-5. What are the "other outcomes of interest"? P24 Line 10. How is "balance" measured? P35 Lines 27-29. Define "consistent" and "less consistent". Quantify "little reporting" P39-40. Are the questions answerable? It seems like this is just reiterating the results rather than providing a summary of whether the question is answered by the systematic review P42 Table 10. Can the duration of participation be added to this table? And to Table 11? P44. Lines 11-15. The summary of findings seems to contradict all of the results that were presented. What is this conclusion based on? P46. Line 48. Define "poor physical health"	We now refer to "benefits". P4 Line 10: We clarified that focus was community level or higher; we focused on participation as part of an organized activity as opposed to an individual level fitness program (see Exclusion criteria). P 5-6: Many studies did not include a comparator; in the full report and Appendixes we provide more details. P7: We attempted to make the primary results clearer. P7 Line 38: corrected P8 Line 16: The text following the sentence with 'quantity, quality, and applicability" clarifies our meanings. P8 Line 41: We appreciate the reviewer's comments (here and below) about defining and quantifying terminology, however, for readability, we chose to leave most statements as written. P 10: The Future research section has been modified. P 10 Line 69: see comment above re further definitions P 11 Lin 12. We could speculate but given the limitations of the research, it is likely that not all important barriers were identified in the included studies. P 22: We added context information in the Discussion section. P 22 Lines 42-45: this statement was modified P 24 Lines 3-5: all outcomes of interest are identified in the methods sections and summary tables P 24 Lines 10: the Appendix tables contain detailed information about the specific measures P 35 Lines 27-29: these statements are based on the arrows tables and are intended to provide an overview of the outcomes; P 39-40: our topic sentence for each section (KQ1a, KQq1b) is that there are few studies so we are not able to provide a definitive answer; we provide the evidence P 42 Table 10, Table 11: we added duration where reported P 44 Lines 11-15: as noted above in response to another reviewer, we modified this section but overall find there is little conclusive evidence about harms associated with adaptive sports due to the limited reporting

Question Text	Comment	Author Responses
	P48. Line 21. Define “cost” Is this monetary? P48. Line 52. Reword. I think you mean that the physical consequences of advanced age prevented participants from engaging in sports. P49. Line 15. Change “genera” to “general” P51. Line 46. This sentence seems incomplete. What does “participation in society” mean? P52. Line 25. Define “attributes” P55. Lines 33-49. These are great topic sentences, but seem removed from the data that was just presented. P55. Lines 48-49. Are these research approaches sufficient? Valid? A good idea? P56. Lines 10-19. Please quantify these conclusions about limitations. How often is “infrequently”? Quantify “many” on this page and throughout P56. Were the questions answered? How are these answers supported? The summary seems to reiterate the results again rather than provide a conclusion based on the results. P57. Under Limitations: How did you conclude that “The quality of evidence was limited and there were few studies for many of the adaptive sports and conditions of interest.”? Quantify “many” “small” “very” “low” “most” How did you conclude that “Results from EAAT, golf, and fly-fishing programs for individuals with PTSD, multiple sclerosis, or history of stroke may not be generalizable to other sports and other populations.”? You state: “Few program studies provided follow-up data to assess whether participation continued and/or whether benefits were maintained.” Why is it important to provide follow-up data? P58. Lines 36-41. Why is this important? And what should specifically be done in future studies that would help address some of the problems that you uncovered? P58. Line 43. Why are long-term effects important? P58. Lines 54-55. Why should studies use a randomized study design? P59. Lines 7-8. Define “helpful information”	P 46 Line 48: This term was used to summarize information from multiple studies so there is no single definition. P 48 Line 21: Costs refers to monetary costs. P 48 Line 52: We have not modified this statement – the studies report “age” or “too old” as barriers. P 49 Line 15: corrected P 51 Line 46: We believe “participation in society” captures the theme identified in the cited studies. P 52 Line 25: Attributes are characteristics (not beliefs). P 55 Lines 33-49: We reviewed and believe they provide a summary of the results. P 55: Lines 48-89: We expand on this in the Future Research section. P 56: Lines 10-19 see comment above regarding quantification P 56: Please see response under Major Comments (#2) above P 57: The summary tables in the Results section provide a good visual overview on which to base conclusions. See comment above regarding quantification It is our sense (no data to support) that a low percentage of individuals participate in equine activities, golf, or fly-fishing (either adaptive sport or non-adaptive sport) If there is an investment in a program (monetary or time), one would want to know whether benefits were maintained. P 58 Lines 36-41: We modified the future research section. P 58 Line 43: see comment above P 58 Lines 54-55: appropriately designed and executed randomized studies provide the best evidence by minimizing risk of bias and allow for statements of cause and effect

Question Text	Comment	Author Responses
	P59. Line 16. What do you mean by “There may be some important barriers not identified.”? Provide more specific information about these potential barriers. P59. Line 18. Define what “gap” means. P59. Line 24. Why is it important to replicate results? What should future studies do to be more generalizable? P59. Lines 27-32. What is the point of these two sentences? P59. Lines 39-46. Define “insufficient” What would be sufficient? This conclusion paragraph seems to undermine the whole point of this review. You state: “Future research could focus on other adaptive sports and populations, other outcomes including harms, and long-term results.” Why? How would this improve the current study?	P 59 Lines 7-8: see comments above about quantifying/defining P 59 Line 16: see above P 59 Line 18 Modified to state a “gap in the evidence.” P 59 Line 24 Replicating results would increase confidence in the findings; P 59 Lines 27-32: These sentences identify sports and medical conditions that might benefit from future research. P 59 Lines 39-46: Insufficient is a standard term in evidence reviews. We modified the conclusion paragraph. The current state of the evidence provides low certainty of evidence to inform future programming.
	There are two important deficits from the report. First, it did not adequately cover sports for powered wheelchair users such as boccia, power wheelchair soccer, and power wheelchair field hockey. Second, there are a number of papers that show the physiological and health (e.g., work capacity benefits) of adaptive sports that are important to be discussed. The VA programs frequently provide an introduction to or improved skills training in adaptive sports and recreation that helps individuals to improve or maintain their physiological capacity and strength/flexibility. These data do not come out in the report.	1) Studies involving the suggested sports for powered wheelchair users would have been included. No studies of those sports were identified. 2) In scoping discussion with our operational partners, it was determined that including studies with only physiologic outcomes (including strength and flexibility) would not be useful for informing clinical practice and policy related to this topic. We agree and believe it is generally accepted that sports participation improves physiologic and health outcomes. We have not included these studies nor provided comment in our report.

APPENDIX D. EVIDENCE TABLES

Appendix D Table 1. Study Characteristics – Included Studies

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Adnan 2001[3] Cross-sectional (matched pairs questionnaire) US Veteran Population: No	Inclusion: male, quadriplegia, ≥1 year experience using a wheelchair Exclusion: none reported	Quadriplegia	Wheelchair rugby	30 (15 wheelchair rugby players, 15 quadriplegic non-players); matched on lesion level	33 (rugby players 30 yrs, non-players 36 yrs)	100%	11.6
Akbar 2015[4] Cross-sectional (questionnaire and Imaging) US Veteran Population: No	Inclusion: paraplegia, wheelchair dependent 24/7 and >5 yrs, mentally healthy, no brain injury, complete information on over-head-sports activity Exclusion: contra-indications for magnetic resonance imaging; cervical disc herniation; advanced degenerative disease of spine; cervical and thoracic syringo-myelia; history of soft tissue injury or surgery of upper	Spinal Cord Injury (100%)	Sport: "overhead-sports activity on a regular basis (at least 1-2 times/wk)"	317 (296 after drop out)	Sports group: 49.1 ± 9.0 No-Sports group: 48 ± 9.7	Sports group: 19.8% male No-Sports group: 30.0% male	Sports group: 26.2 No-Sports group: 25.2

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
	extremity; active infection of shoulder						
Aydoğ 2006[7] Cross-sectional with comparator US Veteran Population: No	Inclusion: free of lower extremity and back problems for previous 6 months, habitually physically active, and no neurological or systematic disorders Exclusion: none reported	Visual impairment: 100% (67% of sample)	Goalball, trained for 1-3	40 (20 active blind, 20 sedentary blind, 20 sighted)	25	60%	NR
Aytar 2012[8] Case series US Veteran Population: No	Inclusion: age ≥18 yrs, male, use of prosthetics ≥4 hours/day, played amputee soccer for ≥2 months prior to start of study Exclusion: any chronic or systemic disease (diabetes mellitus, hypertension, heart disease); bilateral limb amputation	Limb amputation: 100%	Amputee soccer: 100% Others include Volleyball: 9% Soccer: 9% Gymnastic: 9% Running: 18% Basketball: 9%	11	25	100%	10 months
Barbin 2008[9] Pre-post (questionnaire)	Inclusion: SCI, use wheelchair for daily ambulation Exclusion: none reported	Spinal Cord Injury (100%)	Sport: "1-week skiing program"	10	32.1	70% male	5.1 (3.3)

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
US Veteran Population: No							
Bauerfeind 2015[10] Longitudinal case series (9-months with questionnaire) US Veteran Population: No	Inclusion: members of Polish National WR team who participated in training camps and tournaments for ≥18 days Exclusion: none reported	SCI: 86% Other: 14%	Wheelchair rugby	14	30	100%	NR
Beinotti 2013[11] RCT US Veteran Population: No Brazil	Inclusion: clinical diagnosis of first or recurrent unilateral CVA, in chronic phase (≥365 days after CVA); age 50-85 yrs; no serious cognitive deficits (assessed by clinical neurologist) no other neurologic, neuromuscular, or orthopedic disease; no participation in any experimental rehabilitation or drug studies Exclusion: CVA relapse or seizure during intervention	CVA, Ischemic 85% Hemorrhagic 15%	Horseback riding therapy (HBRT)	24, 20 completed HBRT + physiotherapy n=10 Physiotherapy only n=10	56	70%	5.9

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Beinotti 2010[12] CCT US Veteran Population: No Brazil	Inclusion: diagnosis of single CVA, unilateral, of both genres; in chronic phase of disease (>365 days), age 30-85 yrs, sequelae of hemiparesis and significant impaired gait; score of ≥ 2 in Functional Ambulation Category Scale, understand simple instructions, no apraxia or hemineglect, ability to stand with or without assistance and walk, ≥1 step with or without assistance Exclusion: neurological pathologies associated with CVA; any other clinical entity resulting in comorbidity such as heart disease, uncontrolled diabetes, cognitive deficits or psychiatric problems; bilateral CVA or other	CVA (hemiparetic), Ischemic 85% Hemorrhagic 15%	Hippotherapy	20 Hippotherapy/ usual care n=10 Usual care only n=10	56	70%	5.8

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
	degenerative distal disease that might interfere with gait training						
Bennett 2017[14] Pre-post US Veteran Population: Yes	Inclusion: Veterans with combat-related disabilities/symptoms of PTS, depression, perceived stress, functional impairment, self-determination, and leisure satisfaction Exclusion: none reported	Combat-related disabilities (some overlap) PTSD: 80% (33/40) TBI: 30% (12/40) Hearing impairments: 40% (16/40)	Horseback riding therapy (HBRT)	57, 40 completing follow-up	35 (range 24-64)	80%	Median 5-6
Bennett 2014[13] CCT US Veteran Population: Yes	Inclusion: Veterans with posttraumatic stress symptoms; an official diagnosis of PTSD, TBI (TBI), polytrauma, blindness, or mental illness required to participate in program Exclusion: none reported	Symptoms of PTSD: 100% <u>Group A (n=10)</u> PTSD n=4; TBI n=4, Limb amputation, Hemiplegic, Epilepsy n=1 each; Visual impairment n=6 <u>Group B (n=12)</u> PTSD n=7; TBI n=7, Limb amputation, Depression n=1 each <u>Controls (n=12)</u>	"Couples" adaptive snow sports (skiing and snowboarding)	Experiment Group A (5 couples, n=10) Experiment Group B (6 couples, n=12) Control (did not participate in Higher Ground, 6 couples, n=12)	Group A 37 Group B 35 Control 41	NR	Group A (n=5) 1-3 yrs n=3; ≥5 yrs n=2 Group B (n=6) 3-4 yrs n=3; ≥5 yrs n=3 Control (n=6) 3-4 yrs n=3; 4-5 yrs n=1; ≥5 yrs n=2

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
		PTSD n=4; TBI n=3, Limb amputation, n=1; Visual impairment n=2; Hearing impairment n=4					
Bennett 2014[15] Qualitative (focus groups) US Veteran Population: Yes	Inclusion: Veterans with combat-related disabilities Exclusion: none reported	PTSD n=28 (100%); TBI n=10, Limb amputation, n=1; Visual impairment n=1; Hearing impairment n=7; 11 Veterans had ≥2 disabilities	Therapeutic fly-fishing (TFF)	28	NR	71%	NR
Blauwet 2017[18] Retrospective cohort US Veteran Population: No	Inclusion: age 18-60 yrs, mobility impairments, registered for community-based adaptive sports program from April 1, 2013 to May 31, 2014 Exclusion: age <18 yrs or >60 yrs, cognitive impairment that prevented being able to follow instructions independently, limited fluency in English	Musculoskeletal, neurologic, other Use of assistive device 78%	Multiple, including water, individual endurance, winter sports, court sports, yoga, horseback riding	Sustainers attended ≥2 sessions n=78 Non-sustainers attended 0-1 sessions n=56	Overall 41	54	NR, (disability present at birth: 22%)

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Blauwet 2013[16] Cross-sectional US Veteran Population: Yes (47% of enrollees were US Veterans)	Inclusion: age ≥22 yrs, ≥1 year after injury, not ventilator dependent, no tracheostomy, no other neuromuscular disease Exclusion: none reported	SCI	Organized sports (multiple, including basketball (21%, 7/33), tennis 18% (6/33), skiing (15%, 5/33), sailing, rowing, and bowling (4 each 36%, handcycling through hunting)	149 33 Participators in organized sports 166 non-participators 70 (47%) overall were Veterans	50	83%	Mean 19
Boninger 1996[19] Cross-sectional US Veteran Population: No	Inclusion: wheelchair racer invited to participate in Wheelchair Sports USA training camp Exclusion: none reported	SCI: 75% (9/12) Lower limb amputation: 17% (2/12) Cerebral palsy: 8% (1/12)	Wheelchair racing	12	33 (24-45)	92% (11/12)	16 (5-26)
Bragança 2018[20] Cross-sectional (focus group and questionnaire) US Veteran Population: No	Inclusion: non-professional athletes Exclusion: none reported	Limb amputation, brain injury, cerebral palsy, MS, muscle dystrophy, spina bifida, and SCI	Wheelchair rugby	61	NR	89%	18-30=38% 31-40=20% 41-50=28% 51-60=12% 60+=3%
Bragaru 2015[21] Cross-sectional	Inclusion: age ≥18 yrs, ≥12 months since diagnosis of upper	Upper limb deficiency: 100%	Sport: “physical exercise 2 times per week for a	175	Athletes: 48.3	61%	All ≥12 months

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
(digital/paper questionnaire) US Veteran Population: No	limb deficiency, recruited through prosthetic manufacturers and rehab facilities Exclusion: none reported		minimum ½ hour/time and minimal duration of 60 min/week of moderately intensive physical activity, with or without game or competition elements, where skills, and physical endurance are either required or to be improved."		Non-athletes: 48.7	(60% athlete, 64% non-athlete)	
Bragaru 2013[22] Cross-sectional (postal survey) US Veteran Population: No	Inclusion: age ≥18 yrs, able to speak and understand Dutch Exclusion: none reported	Lower limb amputation: 100%	Sport: "participation more than 5 hours per month"	780	59.6	62%	20.4 (245.1 months)
Bragaru 2013[23] Cross-sectional (in-person semi-structured interview) US Veteran Population: No	Inclusion: age ≥18 yrs, ≥12 months since limb amputation, amputation more proximal than ankle, able to speak and understand Dutch Exclusion: none reported	Lower limb amputation: 100%	Sport: "an activity involving physical exertion with or without game or competitive elements, with a minimal duration of ½ hour/time and minimal duration of 60 min/week, and	26	Athletes: 50 Non-athletes: 65	73% (69% athlete, 77% non-athlete)	All ≥12 months

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
			where skills and physical endurance are either required or to be improved"				
Calsius 2015[25] D'hooghe 2014[37] Pre-post (hiking trip) US Veteran Population: No	Inclusion: mild/moderate neurological disability (EDDS ≤4) Exclusion: declined to participate (n=1)	Multiple Sclerosis: (100%)	5 day climbing expedition	9	42 (median)	33%	9 (median)
Campayo-Piernas 2017[26] Cross-sectional with comparator (EMG measurements during balance test) US Veteran Population: No	Inclusion: soccer players with visual impairment at B1 level Exclusion: none reported	Visual Impairment at B1 level: (18%)	Soccer players (57%)	38	28.5 (n=15 sighted soccer players: 25.1; n=6 sighted sedentary: 28.0; n=7 blind soccer players: 28.4; n=10 sighted healthy 32.7)	NR	NR
Carin-Levy 2007[29] Cross-sectional (scripted semi-structured	Inclusion: disabled divers, responded to advertisement Exclusion: congenital impairment or trained	Spinal cord injury: (66%) BK amputation: (33%)	Scuba divers (100%)	3	44	100%	12

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
telephone interviews) US Veteran Population: No	as divers before disability						
Carless 2013[31] Carless2014[30] Cross-sectional (narrative life story interviews) US Veteran Population: No (UK Army members)	Inclusion: attendee at Battle Black Centre, UK intervention for injured military personnel, 11/24 men were interviewed in 2013 paper based on "emerging rapport and positive relationship between first author" Exclusion: none reported	2014: 1 leg amputation 1 gunshot wound to head w/ paralysis 2 SCI patients 4 PTSD patients	Basketball, Badminton, Volleyball, archery, bowling Adventure training: indoor rock climbing, caving, clay pigeon shooting, kayaking	2013: 11 2014: 6 (subset of 11)	2013: 20-43 2014: 19-28	100%	NR
Chard 2017[32] Cross-sectional (scripted semi-structured telephone interview) US Veteran Population: No	Inclusion: age ≥18 yrs, MS diagnosis, engaged in water-based exercise in past 6 months Exclusion: none reported	Multiple Sclerosis (100%)	Aquatic sports: General (low impact): (40%) MS-specific: (28.9%) Laps: (13.3%) Lap + General: (11.1%) General + MS-specific: (6.7%)	45	≥18	22%	16.3
Côté-Leclerc 2017[33]	Inclusion: age 18-64 yrs; use manual wheelchair daily;	Quantitative Study Paraplegia (52.9%) Tetraplegia (20.5%)	Quantitative Study Athletics (23.6%) Tennis (23.6%)	34 (Quantitative)	37.7 (Quantitative)	73.5 (Quantitative)	NR

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Mixed-methods with comparator (standardized outcome measure; semi-structured interview) US Veteran Population: No	played an adaptive sport at least once per week for 4 months; not presenting with cognitive problems Exclusion: none reported	Limb amputation (5.9%) Cancer (5.9%) Other (14.8%)	Rugby (17.6%) Paracycling (14.7%) Basketball (8.8%) Other (11.8%)	10 (Qualitative)	39.2 (Qualitative)	50 (Qualitative)	
Curtis 1999[34] Cross-sectional (self-report survey) US Veteran Population: No	Inclusion: female wheelchair basketball player at National Women's Tournament in 1997 Exclusion: none reported	SCI (39.1%) Lower extremity musculoskeletal and neuromuscular disability (28.3%) Polio (13%) Spina Bifida (10.9%) Limb amputation (8.7%)	Basketball (100%)	46	33.2	0%	12.5 (years of wheelchair use)
da Silva 2018[35] Cross-sectional with comparator (researcher administered questionnaires) US Veteran Population: No	Inclusion: visually impaired football or goalball players (3 months to 29 yrs experience) or physical active sighted individuals; free of bone and/or musculoskeletal and neurological disorders or any chronic joint pain in past 6 months	Visual Impairment at B1 level: 100%	Goalball (58%) Football (41.6%)	12 VI athletes 12 sighted active controls	VI: 31.5 Sighted: 26.0	66.7%	11.3 (excluding athletes with congenital visual impairment)

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
	Exclusion: none reported						
Earles 2015[38] CCT US Veteran Population: No	Inclusion: ≥1 Criterion A traumatic event on the Life Events Checklist; current PTSD Checklist-Specific (PCL-S) Exclusion: PCL scores <31	PTSD: 100%	Hippotherapy	16	51	25%	19 (1-39)
Fiorilli 2013[42] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: men from Italian wheelchair basketball teams competing at National level (athletes) or from different Italian associations for disabled people (non-athletes), lower limb impairment produced by spinal cord injuries in lumbar section (paraplegic subjects), and amputation over the knee Exclusion: concomitant upper body disabilities or presence of metabolic or chronic degenerative	SCI or limb amputation	Wheelchair basketball	46 (24 athletes, 22 non-athletes)	36	100%	26

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
	pathology, and/or motor disabilities resulting from neurodegenerative disease or cerebral injury						
Foreman 1997[43] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: age 16-60 yrs, diagnosis of paraplegia or quadriplegia, and injury occurred ≥12 months prior to study Exclusion: none reported	SCI: 100%	Sport: organized event at least once per fortnight for the last 3 months Basketball: 37% Rugby: 35% Tennis: 7% Road racing: 7% Athletics: 9% Swimming: 4%	121 (54 active vs 67 nonactive)	Active: 32 Nonactive: 38 P=.001	84%	Active: 21 yrs at injury Nonactive: 25 yrs at injury P=.004
Fullerton 2003[44] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: primarily manual wheelchair users Exclusion: none reported	SCI: 86% Others included lower-limb amputation, spina bifida, or unknown	Basketball: 51% Tennis: 26% Rugby: 23% Racing: 19% Skiing: 5% Handcycle: 5% *Athletes* met at least 2 of 3 criteria: 1) trained ≥3 hrs/week; 2) were involved in ≥3 competitions per year; 3) had a wheelchair	257 (172 athletes, 85 non-athletes)	38	NR	NR

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
			modified for sports				
Garshick 2016[45] Cross-sectional with comparator (questionnaire) US Veteran Population: No (1 of 5 recruitment sites was VA facility)	Inclusion: traumatic SCI; ≥1 year post-injury; from 5 SCI referral centers Exclusion: none reported	SCI	"organized sports"	347 with complete data	45	84	9.2
Giacobbi 2008[46] Cross-sectional (questionnaire and semi-structured interview) US Veteran Population: No	Inclusion: age 18-54 yrs with ≥1 condition that impacted activities of daily living Exclusion: none reported	Paraplegia: 54% Quadriplegia: 4% Limb amputation (bilateral or single): 12% Cerebral palsy: 8% Spina bifida: 4% Chronic pain: 4% Fusion of spine: 4% NS: 12%	Wheelchair basketball	26	31	46%	NR
Hammer 2005[49] Pre-post assessment US Veteran Population: No	Inclusion: MS diagnosed by neurologist Exclusion: on-going relapse, participation in therapeutic riding in	Multiple sclerosis	Therapeutic riding	13 enrolled, 11 completed	48	15% of enrolled, 18% of completers	10

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
	past 6 months, body weight >85 kg						
Hanson 2001[50] Cross-sectional (Questionnaire) US Veteran Population: No	Inclusion: age ≥18 yrs, medically stable, and cognitively intact Exclusion: none reported	SCI: 100%	Athlete: wheelchair user with an SCI who participated in aerobic wheelchair sports ≥4 hrs per week or exercised ≥3 times per week for ≥30 minutes each session	48 (30 athletes vs 18 nonathletes)	37	75%	14
Hawkins 2011[52] Observational (interviews) US Veteran Population: Yes, injured service members	Inclusion: age 18-55 yrs, physical disability, member of armed services Exclusion: none-reported	Limb amputation: 60% TBI: 20% SCI: 20% Other: 10%	Multiple (US Paralympic Military Sport Camp – included cycling, strength and conditioning, archery, volleyball, swimming, track and field, and rowing)	10 (of 50 in program); volunteered for interview	20-30 yrs: 90% 30-40 yrs: 10%	90%	< 1 yr: 20% ≥1 to 3 yrs: 60% >3 yrs: 20%
Haykowsky 1999[53] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: qualified and competed at the 1994 Canadian Blind Sports Association National Powerlifting Championships	Visual impairment: 100%	Powerlifting	11	37	82%	NR

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	Exclusion: none reported						
Herzog 2018[54] RCT (cross-over) US Veteran Population: No	Inclusion: age ≥18 yrs, recruited from out-patient physio-therapy department, AIS stable for ≥6 months, able to sit in wheelchair ≥4 hours, able to lean upper body forward ≥20 deg Exclusion: progressive SCI pathologies, known dysfunction of vestibular system, severe visual restriction, acute pain, restricted arm or hand function	SCI (traumatic and non-traumatic): 100%	Indoor wheelchair curling	13	52	54	NR
Jaarsma 2014[55] Cross-sectional (questionnaire – on-line or telephone) US Veteran Population: No	Inclusion: age ≥18 yrs, registered with 1 of 3 centers of expertise for people with visual impairment in Netherlands or attending an exhibition for people with visual impairments Exclusion: none reported	Visual impairment: 100% Self-reported: Mild 10% Moderate 31% Severe 46% Total 9% Other 4% (no difference between active and inactive groups)	"An activity involving physical exertion with or without a game or competition element with a minimal duration of 30 min for at least 2 times a week where skills and physical endurance are	648 (411 active, 237 inactive) (13% response rate)	49 49 active, 49 inactive)	48 (47% active, 49% inactive)	NR

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
			either required or to be improved"				
Jackson 1996[57] Cross-sectional (physical examination) US Veteran Population: No	Inclusion: participant in wheelchair basketball tournament in US Exclusion: none reported	Paraplegia: 58% Limb amputation: 18% Polio: 9% Miscellaneous: 15%	Wheelchair basketball: 100%	33	36	100%	20
Johnson 2018[58] RCT (wait list control) US Veteran Population: Yes	Inclusion: age ≥18 yrs, US Veterans (no longer in active military service including reserves), weight ≤220 pounds, able to walk ≥ 25 feet without assistance of a person, willing to interact with and ride a horse, diagnosis of PTSD or PTSD and TBI, living within 50 miles of riding site Exclusion: none reported	PTSD or PTSD+TBI	Therapeutic horseback riding (100%)	38 enrolled (9 did not receive intervention, 29 randomized, 28 completed baseline data collection, 23 completed week 3 data collection, 19 completed week 6 data collection)	54.4	84.2%	NR
Jolk 2015[59] Case series, pre-post	Inclusion: age 18-65 yrs, diagnosis of MS, no previous experience with sports climbing, score of 1-6	Multiple sclerosis: 100%	Sports climbing: 100%	7	32	14	4.6

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
(evaluation, self-report of injuries) US Veteran Population: No	on Expanded Disability Status Scale, willing to participate in program, no relapse or unstable medication status for at least past 30 or 90 days (respectively) Exclusion: any medically unstable conditions, contraindications (*eg*, severe cardiovascular or respiratory conditions, pulmonary disease, clinically relevant internal disease, severe orthopedic diseases						
Kars 2009[60] Cross-sectional (survey) US Veteran Population: No	Inclusion; age 18-80 yrs, level of amputation proximal to a Syme amputation (*eg*. transtibial, knee disarticulation, transfemoral) Exclusion: admitted to nursing home, not prescribed a prosthesis	Amputation (lower limb): 100%	"An activity involving physical exertion with or without a game or competition element with a minimal duration of half an hour, and where skills and physical endurance are either required or to be improved"	107 (37% response rate; 2 subsequently excluded – limb amputation site did not meet inclusion criteria)	Sports-participating: 55.5 Non-sports-participating: 60.2 (P=.03)	66	Sports-participating: 16.6 Non-sports-participating: 12.5 (P=.06)

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Kim 2017[61] Cross-sectional (survey) US Veteran Population: Yes	Inclusion: qualifying disability, registered to participate in NVWG Exclusion: none reported	SCI: 75% Amputation: 16% MS: 8% TBI: 7% Stroke: 3%	NR	302 (of 643 registered for NVWG)	54.8	91%	20.6
Laferrier 2015[63] Cross-sectional (questionnaire) US Veteran Population: Yes	Inclusion: active duty service members or Veterans with a disability participating in NVWG, WSC, or US Olympic Committee Warrior Games Exclusion: unable to complete question-naires or severe TBI	TBI (mild or moderate): 43% SCI: 34% PTSD: 20% Limb amputation: 17% Other: 6%	Sport NS, included team, combination, and individual events	220	40	86%	NR
Lanning 2013[64] Pre-post (questionnaires and interview) US Veteran Population: Yes	Inclusion: Veterans with 1 to 3 deployments to Iraq and/or Afghanistan Exclusion: none reported	PTSD: 85% TBI: 23% CVA: 8% Other physical disabilities: 69%	Therapeutic riding (equine assisted activity): 100%	13	36	77	NR
Lape 2018[65] (see also Blauwet 2017)[18]	Inclusion: participants from community-based adaptive sports program (see Blauwet 2017) who agreed to	SCI: 24% TBI: 18% Multiple sclerosis: 12% Cerebral palsy 18%	Multi-sport program: 53% Cycling: 47% Sailing 24% Golf: 24%	17	15-29: 18% 30-44: 24% 45-60: 41% 60+: 18%	18%	NR

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Cross-sectional (focus groups) US Veteran Population: No	be in focus groups, mobility or sensory impairment, no concomitant cognitive impairment, age 18-60 yrs, able to speak/write English Exclusion: none reported	Other: 29%	Rowing: 18% Kayaking: 18% Nordic skiing: 12% plus others (each ≤12%)				
Lastuka 2015[66] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: currently practicing wheelchair basketball or rugby Exclusion: none reported	SCI: 81% Limb amputation: 4% Muscular dystrophy: 2% Polio: 2% Spastic paraparesis: 2% Transverse myelitis: 2% Miscellaneous: 5%	Wheelchair basketball: 76% Wheelchair rugby: 24%	131	36	97%	32% from birth
Lindroth 2015[67] Pre-post case-series US Veteran Population: No	Inclusion: age 25-60 yrs; MS diagnosis, BBS score <51, no current exacerbation of MS or exacerbation within last 6 months; ability to stand unsupported for 10 seconds, no orthopedic or medical conditions related to MS diagnosis, no prior	Multiple sclerosis: 100%	Hippotherapy	3	52 (37-60)	33%	Range 5->30

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
	hippotherapy or adaptive riding experience, physician referral for physical therapy Exclusion: none reported						
Litchke 2012[68] Cross-sectional (interview and observation) US Veteran Population: No	Inclusion: male, wheelchair rugby athletes (nationally competitive teams), injured at approximately 17 years, complete lesions at C6 or C7 Exclusion: none reported	SCI (tetraplegia): 100%	Wheelchair rugby: 100%	5	27 (range 17 to 35)	100%	10 (range: 0.8 to 18)
Littman 2017[69] Cross-sectional (semi-structured interview) US Veteran Population: Yes	Inclusion: lower limb amputation (unilateral or bilateral, toe or more proximal) ≥6 months prior to interview, US military Veteran, receiving care at the VA, and reporting >60 min per week of aerobic physical activity Exclusion: none reported	Limb amputation:100% (59% at or below knee, 19% above knee, 22% bilateral and/or upper and lower limb amputation)	Light exercise: sporadic sports or weightlifting, walking, wheeling, or cycling regularly for exercise High exercise: regular weightlifting, sports, running	27	54	100%	0.5-<1=15% 1-4=33% 5-9=19% 10-19=15% 20-29=0% 30-39=7% 40-44=11%

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Lundberg 2011[70] Pre-post (questionnaire) US Veteran Population: Yes	Inclusion: Veterans participating in Higher Ground adaptive sports program Exclusion: none reported	*Participants identified multiple acquired disabilities* TBI: 83% PTSD: 50% Visual impairment: 38% Amputation: 27% Orthopedic impairment (including SCI): 55% Depression: 28%	3 separate groups 1) water skiing, kayaking, river rafting, canoeing, and fly-fishing over 5 days (5 Veterans + significant others) 2) fly-fishing camp for 5 days (6 Veterans + significant others) 3) ski/snowboard, ice skating, Nordic skiing over 5 days (7 Veterans + significant others)	18	30-34 (average age)	NR	NR
Malinowski 2017[75] Pre-post (in-person administration) US Veteran Population: Yes	Inclusion: Veterans with previous PTSD diagnosis Exclusion: none reported	PTSD: 100%	Equine-Assisted Activities and Therapies (EAAT), 5 sessions/days with a licensed therapist and certified equine specialist.	7	58	86%	NR
McVeigh 2009[76] Cross-sectional (scripted semi-structured telephone interview)	Inclusion: Canadian residents, age ≥16 yrs, injury level at C5 or below of any etiology, injured ≥12 months prior to interview, community	SCI (C5 or below): 100%	Team: 76% Individual 24% Recreational: 18% Organized competitive: 33%	90 (45 sport participants, 45 non-sport participants)	16-30 yrs: 21% (22% sport, 20% non-sport) 31-50 yrs: 58% (71%	79% (84% sport group, 73% non-sport group)	All ≥12 months 1-5 yrs: 31% (24% sport, 38% non-sport)

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
US Veteran Population: No	living, wheelchair dependent ≥1 hour per day outside of sport activity Exclusion: hospitalized at time of interview Recruited at outpatient clinic and fitness center of rehabilitation clinic and at organized wheelchair sporting events		Elite/professional: 49% ≥3 times/week: 78% 1-2 times/week: 22% 1-3 times/month: 0%		sport, 44% non-sport) >50 yrs: 21% (7% sport, 36% non-sport)		6-10 yrs: 13% (11% sport, 16% non-sport) >10 yrs: 56% (64% sport, 47% non-sport)
Miki 2012[77] Cross-sectional (self-administered questionnaire) US Veteran Population: No	Inclusion: persons with SCI participating in wheelchair basketball games in Japan Exclusion: none reported	Spinal cord injury: Tetraplegia: 26% Paraplegia: 74%	Wheelchair basketball: 74% (paraplegic participants) Wheelchair twin basketball (twin hoops at different heights for different shooting abilities): 26% (tetraplegic participants)	81	<30 yr: 34% 30-39 yr: 43% >40 yr: 23%	100%	<13 yrs: 48% >13 yrs: 43% NR: 9%
Molik 2010[78] Cross-sectional (self-	Inclusion: participants in Polish League of Wheelchair Basketball, Polish	NR	Wheelchair basketball: 26%	174	26	Wheelchair basketball: NR	NR

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administered questionnaire) US Veteran Population: No	League of Wheelchair Rugby, or "practicing boccia" Exclusion: none reported		Wheelchair rugby: 36% Boccia: 38%			Wheelchair rugby: 98% Boccia: NR	
Mowatt 2011[79] Cross-sectional (narratological study of letters from participants) US Veteran Population: Yes	Inclusion: participants in therapeutic fly-fishing program with confirmed diagnosis of PTSD Exclusion: none reported	PTSD: 100%	Fly-fishing: 100%	67	NR	NR	NR
Muñoz-Lasa 2011[80] Pre-post with comparator (CCT) (in-person assessment) US Veteran Population: No	Inclusion: age 18-65 yrs, able to walk at least 10 m (with or without technical aids) Exclusion: important comorbidity, previous riding experience, EDSS <2 or >6.5, pregnancy, or clinical instability	Multiple Sclerosis: 100%	Therapeutic horseback riding: 44% Traditional physiotherapy (comparator): 56%	27	46	41%	8
Muraki 2000[81] Cross-sectional (self-	Inclusion: individuals with SCI living in Western Japan who finished a hospital rehabilitation program	Spinal cord injury: Tetraplegia: 22% Paraplegia: 78%	Wheelchair basketball: 13% Wheelchair racing: 11%	32	41	100%	NR

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administered questionnaire) US Veteran Population: No	and were living in the community Exclusion: female or >60 yrs surveyed but excluded from analysis		Wheelchair tennis: 8% Archery: 4% Gateball: 2% Wheelchair table tennis: 2% Other: 3%				
Nam 2016[82] Cross-sectional (self-administered questionnaire) US Veteran Population: No	Inclusion: living in South Korean community, adequate communication function, regularly participating in activities at sports club for disabled Exclusion: none reported	Spinal cord injury: Tetraplegia: Paraplegia: 85% Tetraplegia: 15%	Wheelchair rugby: 47% Lawn bowling: 45% Wheelchair basketball: 8%	62	43	85%	13
Nettleton 2017[83] Pre-post (self-administered questionnaires) US Veteran Population: No	Inclusion: attendees of return to sport exhibition for people with a disability, age ≥18 yrs, any disability, able to provide consent Exclusion: none reported	Acquired brain injury: 15% Spinal cord injury: 36% Cerebral palsy: 8% Intellectual disability: 8% Neuromuscular disease: 8% Limb amputation: 14% Other: 13%	Multiple Examples: wheelchair rugby, climbing, ten-pin bowling, powerchair football	39	35	74%	NR

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O'Neill 2004[85] Cross-sectional (telephone administered questionnaire) US Veteran Population: No	Inclusion: admitted for de novo rehabilitation in hospital spinal cord unit serving Northern Ireland (surveyed 9-23 months post-discharge) Exclusion: none reported	Spinal cord injury: Paraplegia: 36% Tetraplegia: 45% Guillain-Barre Syndrome: 18%	Sports introduced during rehabilitation: Bowling: 58% Archery: 39% Swimming: 36% Table tennis: 21% Basketball: 3% Darts: 3%	33	<45 yrs: 61%	60%	NR
Perrier 2015[87] Perrier 2012[86] Cross-sectional with comparator (questionnaire/ interview) US Veteran Population: No	Inclusion: age ≥18 yrs, permanent physical disability acquired at age 16 or older; completed inpatient rehabilitation, no cognitive or memory impairments (by self-report), English speaking Exclusion: none reported	SCI: 76% Limb amputation: 15% Other: 9%	Defined as "structured physical activity between 2 or more people in a competitive event where a winner can be determined"	216 enrolled, 201 completed **Non-intenders** (not engaged in sport/not thinking about it): 28% **Intenders** (considering engaging in sport in next 6 months or making plans for sport): 10% **Actors** (currently involved in an adapted sport): 62%	44 Non-intenders: 52 Intenders: 43 Actors: 41	59 Non-intenders: 54 Intenders: 29 Actors: 67	16 Non-intenders: 21 Intenders: 11 Actors: 16
Pluym 1997[89] Cross-sectional	Inclusion: age 18-65 yrs, wheelchair-bound due to an acquired disability, and residing	SCI: 52% Limb amputation: 2%	Wheelchair tennis, wheelchair basketball, wheelchair	44	38	61%	NR

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
US Veteran Population: No	independently in community Exclusion: none reported	Upper motor neuron leisure: 16% Orthopedic disease: 9% Neuromuscular disease: 5% Others: 16%	badminton, swimming, quad rugby, wheelchair dancing				
Ponchillia 2002[90] Cross-sectional (telephone survey) US Veteran Population: No	Inclusion: current USABA members with athlete status Exclusion: none reported	Visual impairment at B1 level: 37% Visual impairment at B2 level: 27% Visual impairment at B3 level: 36%	Highest level of participation in goalball, track and field, alpine skiing, swimming, wrestling, tandem cycling, power lifting, judo, Nordic skiing, and gymnastics	159	25 (24% under 15 yrs)	64%	55% from birth, 19% <12 yrs
Rauch 2014[92] Cross-sectional (survey) US Veteran Population: No	Inclusion: members of the Swiss Paraplegic Association with traumatic or non-traumatic SCI, age >18 yrs, and living in community ≥1 year Exclusion: none reported	SCI (paraplegia): 71% SCI (tetraplegia): 28%	NS, performed for ≥30 minutes	599	49	74%	18
Rogers 2014[93] Pre-post (questionnaires)	Inclusion: age ≥18 yrs, Veterans of OEF, OIF or both; seeking care for mental health	PTSD 79% Depression: 7% Both: 14%	Ocean Therapy (surfing): 100%	14	<24 yrs: 21% 24-30 yrs: 72% >30 yrs: 7%	93	NR

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US Veteran Population: Yes	concerns at VA Post Deployment Clinic; enrolled to attend program but hadn't participated yet; physician-reported diagnosis of PTSD, major depressive disorder, or both Excluded: non-English speaking						
Sa 2012[94] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: reduced mobility in greater Porto area, contacted through rehabilitation centers and physiotherapy clinics Exclusion: none reported	Paraplegia: 100% (25% with reduced upper limb mobility)	NS physical activity/sport	24 (5 active vs 19 inactive)	33	NR	NR
Scarpa 2011[95] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: age 13-28 yrs Sport group: regular practice for ≥12 months (1-1.5 hours, 2-3 times per week) Disabled group: Presence of peripheral (SCI) or central (cerebral palsy) paraplegia	SCI: 93% Cerebral palsy: 6%	Sport NS	143 (109 active and disabled, 34 inactive with disability)	20	50%	NR

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	Exclusion: none reported						
Schachten 2015[96] CCT (matched pairs) US Veteran Population: No	Inclusion: age 23-72 yrs, recovering from CVA Exclusion: none reported	CVA: 100%	Golf	14 (7 matched pairs)	54	NR	4
Shatil 2005[97] RCT US Veteran Population: No	Inclusion: cerebrovascular accident resulting in hemiparesis ≥6 months prior to study, medically stable, no coexisting neuro-musculoskeletal disorders affecting balance or quality of life, able to stand unsupported for 60 seconds, community living, interest in golf with no participation in regular activities >1 time per week, not participating in regular outpatient physiotherapy intervention	CVA: 100%	Golf	18 (10 golf training, 8 hand therapy) NOTE: Hand therapy group crossed over to golf	64	61%	4 yrs (50 months)

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	Exclusion: none reported						
Silkwood-Sherer 2007[99] CCT (non-equivalent pre-test/post-test) US Veteran Population: No	Inclusion: age ≥18 yrs, ability to stand with or without an assistive device for 1 minute, no orthopedic or medical problems unrelated to MS, no previous experience with hippotherapy or therapeutic riding, no allergies or aversions to horses, weight <240 lbs, and physician referral Exclusion: none reported	Multiple sclerosis: 100%	Hippotherapy	15 (9 intervention group, 6 control group)	Intervention group: 42 Control group: 48	Intervention group: 44% Control group: 33%	Intervention group: 10 (0.5-26) Control group: 13 (3-25)
Silveira 2017[100] Cross-sectional US Veteran Population: No	Inclusion: men, age ≥18 yrs, identify as having tetraplegia, involvement in competitive wheelchair rugby league as part of a team Exclusion: none reported	SCI: 87% Other injuries included cerebral palsy, cancer, and limb amputations	Wheelchair rugby	150	35	100%	16
Skordilis 2001[101]	Inclusion: involved in basketball or	SCI: 53% Spina Bifida: 9%	Basketball: 80%	243	NR	82%	Childhood (0-12 yrs): 33%

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Cross-sectional (questionnaire) US Veteran Population: No	marathon racing at national level Exclusion: participants in both sports or no sports	Limb amputation: 14% Polio: 9% Cerebral Palsy: 2% Other: 13%	Marathon racing: 20%				Adolescence (13-19 yrs): 32% Adulthood (≥20 yrs): 35%
Skučas 2013[102] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: age 18-45 yrs with SCI Exclusion: none reported	SCI: 100% (26% tetraplegic, 74% paraplegic)	Sport NS	106 (33 active, 73 inactive)	NR	70%	Range 2-15
Sporner 2009[103] (National Veterans Wheelchair Game and Winter Sports Clinic) Cross-sectional (self-report questionnaire) US Veteran Population: Yes	Inclusion: participants in WSC or NVWG expressing interest in research study Exclusion: none reported	SCI: 43% Limb amputation: 33% Visual impairment 6% Multiple sclerosis: 8% Other: 9%	Organized sports (rugby, basketball, skiing) Non-organized sports (“ball sports”, snow sports, outdoor recreation, “water sports”, track & field, cycling, physical fitness)	132	47.4	87%	13.5
Stephens 2012[104]	Inclusion: acquired SCI and permanent wheelchair user	SCI: 100% (57% tetraplegic, 43% paraplegic)	Wheelchair basketball: 29% Wheelchair rugby: 57%	7	38	86%	13 (4-33)

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Cross-sectional (semi-structured interview) US Veteran Population: No	Exclusion: none reported		Wheelchair tennis: 14%				
Tasiemski 2004[106] Tasiemski 2005[107] Cross-sectional (questionnaire) US Veteran Population: No	Inclusion: SCI (level C5 or below) for ≥1 year, wheelchair dependent, ASIA grade A, B, or C, age 18-50 yrs at time of injury; admitted to spinal unit within 6 months of injury, resident of United Kingdom Exclusion: none reported	SCI at C5 or below: 100%	International (Paralympic medalists and World Championship medalists), national, and regional athletes Swimming, archery, weigh-training, basket-ball, and table tennis most common (2005)	985	45 48 (2005)	84% 81% (2005)	19.5 (2005)
Tasiemski 2011[105] Cross-sectional (questionnaires) US Veteran Population: No	Inclusion: presence of SCI (level C5 of below) for ≥1 year before study; using manual wheelchair for all daily activities, age 18-50 yrs at time of injury, admitted to rehabilitation center within 6 months of injury, resident of Poland	SCI at C5 or below: 100%	Team and individual sports	1034	36	83%	9.8

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
	Exclusion: none reported						
Tasiemski 2012[108] Cross-sectional (questionnaires) US Veteran Population: No	Inclusion: practiced competitive tandem cycling in Poland, belonged to sports clubs for visually impaired, held a competitive cycling license Exclusion: none reported	Blind: 52% Visual impairment: 48%	Tandem cycling	50 (25 disabled vs, 25 able bodied)	Dis-abled: 37 Able bodied: 33	72%	NR
Taylor 1996[109] Cross-sectional (interview) US Veteran Population: No	Inclusion: SCI who had participated in sea kayaking expeditions through an outdoor experience organization specifically created for persons with disabilities and nominated by a recreational therapist Exclusion: none reported	SCI: 100%	Sea kayaking	3	30	67%	5
Urbański 2013[110] Cross-sectional (questionnaires)	Inclusion: recruited from 2 rehabilitation units in Poland	SCI: 100%	Team sports: Wheelchair rugby (23%)	30 (15 individual sports, 15 team sports)	Team sport: 32	90%	NR

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
US Veteran Population: No	Exclusion: none reported		Wheelchair basketball (10%) Boccia (10%) Unihockey (7%) Individual sports: Wheelchair racing (13%) Powerlifting (10%) Swimming (10%) Wheelchair fencing (10%) Alpine skiing (7%)		Individual sport: 31		
Velikonja 2010[112] RCT US Veteran Population: No	Inclusion: relapsing-remitting MS, primary progressive MS or secondary progressive MS, age 26-50 yrs, EDSS <6 and EDSS pyramidal functions score >2 Exclusion: none reported	Relapsing-remitting MS:100%	Sports climbing Yoga	20	Sports climbing: Median 42 Yoga: Median 41	NR	NR
Vella 2013[113] Pre-post (questionnaires) US Veteran Population: Yes	Inclusion: Veteran who served in a foreign country with confirmed diagnosis of PTSD or exhibiting a clinically relevant score on the PTSD checklist (military version); dual	PTSD: 100%	Fly-fishing	74 (96 randomized)	47	93%	NR

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
	diagnosis of PTSD/ major depressive disorder or PTSD/ TBI permitted Exclusion: dual diagnosis with Axis 1 disorder from DSM IV other than PTSD or major depressive disorder						
Vermöhlen 2017[114] RCT US Veteran Population: No	Inclusion: age ≥18 yrs with confirmed MS, spasticity of lower limbs, and EDSS between 4 and 6.5 Exclusion: hippotherapy in last 12 months, body weight >90 kg, no balance while sitting, and acute exacerbation 4-weeks before start of therapy	Multiple sclerosis: 100%	Hippotherapy	ITT 67/70 randomized (30 interventions vs 37 control)	Median 51 yrs	19%	Median 17.3 yrs
Wickham 2000[115] Pre-post (questionnaires) US Veteran Population: No	Inclusion: participated in 1998 wheelchair sports camp; control group did not participate in camp Exclusion: none reported	Multiple sclerosis: 100%	Wheelchair basketball, quad rugby, wheelchair tennis, swimming, weight-lifting, and wheelchair racing	24 (camp participants vs non-camp participants)	35	67%	5

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Wu 2000[116] Cross-sectional (questionnaires) US Veteran Population: No	Inclusion: SCI individuals living in the United Kingdom Exclusion: none reported	SCI: 100%	Wheelchair basketball, wheelchair rugby, wheelchair tennis, and wheelchair athletics	143 (112 active vs 31 inactive)	33	92%	11
Yazicioglu 2012[117] Cross-sectional with comparator (questionnaires) US Veteran Population: No	Inclusion: age ≥18 yrs, injured ≥12 months, had physical disabilities that consisted of paraplegia or limb amputation Exclusion: none reported	Paraplegia: 52% Limb amputation: 48%	Basketball (30%), archery (30%), air pistol shooting (13%), amputee football (27%)	60 (participants vs non-participants)	30	87%	NR
You 2016[118] Cross-sectional (questionnaires) US Veteran Population: No	Inclusion: wheelchair athletes enrolled from March-May 2015 Exclusion: history of surgical treatment for injuries to upper extremity, history of visiting a clinic for shoulder pain in past 6 months; unwilling-ness to participate in research, or mean means of transportation was to a manual wheelchair	SCI: 89% Limb amputation: 9% Polio: 3%	Table-tennis (TT), archery (AR)	36 (19 TT vs 16 AR)	48	69%	25

Author, year Study Design (Method of Data Collection[a]) US Veteran Population (Yes/No)	Study Inclusion/ Exclusion Criteria	Medical Condition(s) (%)	Sport(s) (%) or Definition/ Characteristics	Number of Participants	Age (years) (mean unless noted)	Gender (% male)	Time from Injury or Diagnosis (years)
Zoerink 2015[119] Pre-post (questionnaires) US Veteran Population: No	Inclusion: adults recovering from CVA and referred by physician Exclusion: none reported	CVA: 100%	Golf	11	62	64%	NR
Zwierzchowska 2017[120] Cross-sectional with comparator (questionnaire) US Veteran Population: No	Inclusion: traumatic cervical SCI at C4-C7 level, >3 yrs post-injury; locomotion via manual active wheelchair Exclusion: injury at age ≤15 yrs, age ≤18	SCI: 100%	Wheelchair rugby	36 (24 rugby players, 12 sedentary wheelchair users)	33	100	12

[a]Method of Data Collection (*eg*, focus group, questionnaire/survey [on-line or in-person], interview)

AIS=American spinal cord injury association Impairment Scale; B1=no or limited light perception, unable to recognize shape of hand; BK=below knee; C#=cervical level; CVA=cerebrovascular accident or stroke; DSM IV=Diagnostic and Statistical Manual of Mental Disorders, 4th Edition; EDSS=Expanded Disability Status Scale; ITT=intention to treat; m=meters; mo=month; MRI=magnetic resonance imaging; MS=multiple sclerosis; NR=not reported; NS=not specified; NVWG=National Veteran Wheelchair Games; OEF=Operation Enduring Freedom; OIF=Operation Iraqi Freedom; PTS=posttraumatic stress; PTSD=posttraumatic stress disorder; RCT=randomized controlled trial; SCI=spinal cord injury; TBI=traumatic brain injury; ULD=upper limb deficiency; USABA=US Association of Blind Athletes; WCS=Winter Sports Clinic (Veterans); VI=visual impairment; yrs=years

Appendix D Table 2. Adaptive Sports Program Description

Author, year Study Design (US Veteran Population (Yes/No) Medical Condition	Sport(s)	Program Duration (weeks)	Program Frequency (sessions per week)	Program Leadership (describe)	Program Component Description
Barbin 2008[9] Longitudinal study (questionnaire) US Veteran Population: No SCI	Skiing program	5 days	5 hours/day	20 specialized physical educators	Practice skiing with an adapted skiing wheelchair
Beinotti 2013[11] RCT US Veteran Population: No CVA	Horseback riding	16 weeks	Once a week, 3 minutes	Instructors and assistants followed specific procedures and comprehensive lesson plans. They were aware of contraindications to HBRT and took appropriate precautions for riders' safety	HBRT sessions were conducted in a sand arena. Patient undergoing HBRT was directed by an instructor and aided by a side-walker who offered as much assistance as necessary. Patients performed activities such as touching various parts of the horse's body, which involved crossing their midline while maintaining appropriate balance and posture. Physiotherapy sessions were 50 minutes, done 3 times/week
Beinotti 2010[12] CCT US Veteran Population: No CVA	Horseback riding	16 weeks	Once a week	NR	Hippotherapy sessions occurred at the Center for Therapeutic Riding Harmony, a sand arena. For the mount an American saddle was used in the first 5 sessions, to give greater balance and stability to the adult and in the other sessions, a suitable blanket for hippotherapy.
Bennett 2017[14] Pre-post US Veteran Population: Yes Combat-related disabilities including PTSD	Fly-fishing	1 week (4 days)	NR	Guides and support staff were experienced at working with veterans (a few were also veterans with combat-related disabilities and similar backgrounds to	Participants were taught basic fly-fishing skills that consisted of 2 days of fly-fishing with a guide, learning how to tie flies, and camping. The program was created to help improve the quality of life for Veterans with disabilities by impacting their emotional, social and physical

Author, year Study Design (US Veteran Population (Yes/No) Medical Condition	Sport(s)	Program Duration (weeks)	Program Frequency (sessions per week)	Program Leadership (describe)	Program Component Description
				the participants)	functioning. Participants for the program were recruited by word of mouth and through health professionals who have contact with Veterans.
Bennett 2014[13] CCT US Veteran Population: Yes PTSD	Skiing or snowboarding	1 week	Skiing and snowboarding twice a day with a mid-week break	Direct service staff, 2 recreational therapists, and the snow sports instructors	Skiing and snowboarding, discussions, and feedback. Higher Ground program specific themes included: (a) how to improve relationships with peers and significant others, (b) developing stress management skills through recreation, (c) learning or relearning recreation skills and how participation in recreation improves life, (d) the need for individual leisure and taking personal time to recharge, and (e) how to apply what they learned to their lives
Bennett 2014[15] Qualitative (focus groups) US Veteran Population: Yes Combat-related disabilities (*eg,* PTSD, TBI, hearing or visual impairment)	Therapeutic fly-fishing (TFF)	4 days	2 days of fly-fishing	Professional fly-fishing guides. The focus groups were conducted on the last night of the participants' TFF experience, around the campfire or the kitchen table to understand participants' perceptions of the TFF program	Program to assist Veterans and their families cope with symptoms related to disabilities and improve functioning. Help reduce negative symptoms of combat-related disabilities and increase positive outcomes
Calsius 2015[25] D'hooghe 2014[37] Pre-post (hiking) US Veteran Population: No MS	Hiking excursion	45 weeks	N/A	MS Center in Melsbroek, Belgium	Longitudinal data collected for 6 months before trip and for 4 months post-trip.

Author, year Study Design (US Veteran Population (Yes/No) Medical Condition	Sport(s)	Program Duration (weeks)	Program Frequency (sessions per week)	Program Leadership (describe)	Program Component Description
Carless 2013[31] Carless 2014[30] Cross-sectional (narrative life story interviews) US Veteran Population: No (UK Army members) Multiple conditions (military-related)	Basketball Badminton Volleyball Archery Bowling Kayaking Clay pigeon shooting Rock climbing Caving	5 days	N/A	UK military intervention for injured personnel	Men spent 5 days at a course and were housed and fed. · Breakfast · Psychological training · Sports/Adventure training with adaptive sport and technical advisor · Review/reflection · Dinner · Social activities
Earles 2015[38] CCT US Veteran Population: No Anxiety and PTSD	Hippotherapy	6 weeks	2 hours/week	Doctor	Group sessions with individual tasks Session 1: met horses and worked to develop noncritical self-awareness and improved concentration and listening skills Session 2: worked on nonverbal interactions with horses Session 3: learned to halter horses and worked on dealing with challenges in stressful situations Session 4: Learned to lead and back up horses Session 5: Learned to stay focused when faced with distraction or temptation Session 6: Review of learned skills and worked on inner stillness and stability
Hammer 2005[49] Pre- post US Veteran Population: No MS	Therapeutic riding	10-11 weeks (10 sessions) Additional 3-4 weeks follow-up	Once per week, 30 minutes per session	Physical therapists (established treatment plan, selected appropriate exercises) Riding instructor (riding safety, instruction) Worked together to select horse and equipment	Individually tailored to physical needs and ability to ride 1) physical exercise (a few minutes) 2) combination of physiotherapeutic components and riding skill

Author, year Study Design (US Veteran Population (Yes/No) Medical Condition	Sport(s)	Program Duration (weeks)	Program Frequency (sessions per week)	Program Leadership (describe)	Program Component Description
Hawkins 2011[52] Cross-sectional (interviews) US Veteran Population: Yes "Injured service members"	Multiple (cycling, strength and conditioning, archery, volleyball, swimming, track and field, rowing)	3 days		Sponsored by US Paralympics division of the US Olympic Committee Military and non-military Paralympians and Paralympic coaches assisted with leading events	
Herzog 2018[54] RCT US Veteran Population: No SCI	Curling (indoor, wheelchair)	8 weeks total (cross-over design with 4 weeks of curling training and 4 weeks of usual activity without curling training)	Twice per week	Experienced physiotherapists trained in wheelchair curling	90 min sessions with 10 min warm-up, 30 min technical training, 40 min playing, 10 min cooldown
Johnson 2018[58] RCT US Veteran Population: Yes PTSD	Therapeutic horseback riding (indoor or outdoor)	6 weeks	Once per week	-Conducted at Professional Associations of Therapeutic Horsemanship (PATH)-Accredited Riding Center -Sessions conducted by PATH-certified riding instructor -OT supervision of sessions -Horses led by riding center volunteer	-Occupational therapist conducted assessment of participants (needs, safety, appropriate horse) -Facility staff matched Veterans with a horse -Systematized curriculum developed by research team -1 hour sessions -Riders learned basic horsemanship skills and completed tasks including grooming and interacting with horse before riding, applying riding tack, mounting, riding, dismount -2 side-walkers for safety/balance

Author, year Study Design (US Veteran Population (Yes/No) Medical Condition	Sport(s)	Program Duration (weeks)	Program Frequency (sessions per week)	Program Leadership (describe)	Program Component Description
Jolk 2015[59] Case series, pre-post US Veteran Population: No MS	Sports climbing (indoor facility)	5 weeks	Once per week	-Experienced instructor (not told that participants had MS)	-2 hour group sessions -Maximum height=15 meters (49 feet) -Routes of varying difficulty -Rested when perceived exertion moderate or higher -Completed 5-20 climbs per session depending on fitness level
Lanning 2013[64] Pre-post (questionnaires and interview) US Veteran Population: Yes Mental and physical wounds	Therapeutic riding (equine assisted activity) Professional Association of Therapeutic Horsemanship (PATH) International Equine Service for Heroes	24 weeks	Once per week, 1-2 hours	PATH International certified instructors involved in training horses	1) Ground activities (grooming, leading, walking by hand) 2) Riding activities (walking, trotting, going around objects, riding over uneven ground) 3) Fellowship time (light meal, social interaction) Participants matched with Veteran volunteer and horse
Lindroth 2015[67] Case-series US Veteran Population: N MSo	Hippotherapy	6 weeks	Twice per week, 40 minutes	Horse handler and 2 side walkers, 1 being a physical therapist	Horses chosen based on participants size and rehabilitation needs. Participants asked to change position on horse.
Lundberg 2011[70] Pre-post (questionnaire) US Veteran Population: Yes Acquired disability (including PTSD, TBI, SCI, vision impairment, limb	Multiple (water sports, fishing, winter sports)	5 days	Time per day NR	NR	Sport participation Daily discussion topics Journaling Debriefing Processing

Author, year Study Design (US Veteran Population (Yes/No) Medical Condition	Sport(s)	Program Duration (weeks)	Program Frequency (sessions per week)	Program Leadership (describe)	Program Component Description
amputation, depression)					
Malinowski 2017[75] Pre-post US Veteran Population: Yes PTSD	Equine-Assisted Activities and Therapies (EAAT)	5 days	Single 1-hour session per day	Licensed therapist and certified equine specialist	Session 1: orientation Session 2: obstacle course & mindfulness Sessions 3-4: horse chalking and active feelings exercise Session 5: termination
Mowatt 2011[79] Cross-sectional US Veteran Population: Yes PTSD	Therapeutic fly-fishing program in Northeastern Utah	4 days (2 fishing)	NR	Professional guide leads fishing	Meals, lodging, transportation, and guides provided
Muñoz-Lasa 2011[80] Pre-post with comparator (CCT) US Veteran Population: No MS	Therapeutic horseback riding vs traditional physiotherapy	20 weeks (with a 4- week resting period between first 10 weeks and second 10 weeks)	Once per week, 30-40-minutes per session	"Instructor"	Progressive challenging of rider's motor skills while maintaining appropriate balance and posture in all body positions
Rogers 2014[93] Pre-post (questionnaires) US Veteran Population: Yes PTSD	Ocean Therapy (surfing)	5 weeks	Once per week, 4 hours	Occupational therapist competent in surf instruction, group processing, ocean lifeguarding, and first aid Program based on resiliency themes: role identity, leadership and trust, community building, problem solving, and transition	Each session: 1) introductory presentation 2) stretching warm-up 3) on-land instruction and practice 4) individual surf lesson with a surf instructor 5) group processing (shared experiences) 6) second surf lesson 7) communal lunch and group discussion
Schachten 2015[96] CCT (matched pairs)	Golf	10 weeks	Twice per week, 1 hour	NR	Instruction for specific golf exercises to enhance cognitive and motor performance.

Author, year Study Design (US Veteran Population (Yes/No) Medical Condition	Sport(s)	Program Duration (weeks)	Program Frequency (sessions per week)	Program Leadership (describe)	Program Component Description
US Veteran Population: No CVA			Mean of 19 sessions completed by participants		
Shatil 2005[97] RCT US Veteran Population: No CVA	Golf	6 weeks	3 times per week, 75 minutes	Golf professional and physiotherapist	Sessions at wheelchair accessible golf practice range. Golf swing analysis of stance, grip, swing plane, weight shift, and posture provided. Golf-related problem list developed for each subject. One session per week at driving range, putting green, or golf course. Goal to improve swing mechanics while maintaining balance and stance. Physiotherapy occurred for 45 minutes, twice weekly.
Silkwood-Sherer 2007[99] CCT (non-equivalent pre-test/post-test) US Veteran Population: No MS	Hippotherapy	14 weeks	Once per week, 40 minutes	Experienced horse handler with 2 side walkers	Held in indoor arena at therapeutic riding center. Subjects placed on horses to respond to changes in horse's movement, not instructed in riding skill.
Velikonja 2010[112] RCT US Veteran Population: No MS	Sports climbing Yoga	10 weeks	Once per week	Sports climbing supervised by 2 licensed instructors. Yoga instructed by a licensed specialist nurse.	Participants were asked to attend ≥9 out of 10 sessions) Climbing wall adjusted for patients with physical disabilities Yoga program adjusted for MS patients
Vella 2013[113] Pre-post US Veteran Population: Yes PTSD	Fly-fishing	3 nights, 2 days	N/A	Trained specialists	Total of 16 hours across 2 days. Excursions varied from 2-7 Veterans. Transportation provided by program.

Author, year Study Design (US Veteran Population (Yes/No) Medical Condition	Sport(s)	Program Duration (weeks)	Program Frequency (sessions per week)	Program Leadership (describe)	Program Component Description
Vermöhlen 2017[114] RCT US Veteran Population: No MS	Hippotherapy	12 weeks	Once per week	Hippotherapists	Hippotherapy added on to standard care, which remained unchanged. Examinations and questionnaires completed at baselines, 6-7 weeks and after 12 wks.
Wickham 2000[115] Pre-post US Veteran Population: No SCI	Wheelchair basketball, quad rugby, wheelchair tennis, swimming, weight-lifting, and wheelchair racing	2 days	N/A	NR	Wheelchair sports camp designed to give persons with physical disabilities the opportunity to explore adapted sports.
Zoerink 2015[119] Pre-post US Veteran Population: No CVA	Golf	6 weeks	Once per week	Social worker, Certified Therapeutic Recreation Specialist, and exercise physiologist	3-hole short course. Each program consisted of 3 phases: (1) 15-20 min warm up, including physical exercise, goal setting, and safety precautions; (2) 30-45 min golfing period; (3) 15-20 min debriefing session

CCT=controlled clinical trial; CVA=cerebrovascular accident or stroke; MS=multiple sclerosis; NR=not reported; NS=not specified; PTSD=posttraumatic stress disorder; RCT=randomized controlled trial; SCI=Spinal Cord Injury; TBI=traumatic brain injury

Appendix D Table 3. Health and Wellness Outcomes – KQ1

Author, year Design Sport Population (n enrolled)	Health		Balance		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
PROGRAM STUDIES						
Beinotti 2013[11] RCT Therapeutic horseback riding CVA (n=24)	*Riding + Conventional therapy* SF-36 General Health, mean (SD) Pre: 75.3 (17.8) Post: 85.9 (15.5) P=.11	*Conventional therapy* SF-36 General Health, mean (SD) Pre: 75.0 (24.4) Post: 77.7 (20.9)			*Riding + Conventional therapy* SF-36 Pain, mean (SD) Pre: 97.5 (7.9) Post: 91.9 (18.5) P=.58	*Conventional therapy* SF-36 Pain, mean (SD) Pre: 63.9 (30.8) Post: 70.6 (27.3)
Beinotti 2010[12] CCT Hippotherapy CVA (n=20)			*Riding + Conventional therapy* BBS, mean (SD) Pre: 46.1 (12.9) Post: 49.0 (13.0) P=.06	*Conventional therapy* BBS, mean (SD) Pre: 44.3 (12.3) Post: 45.1 (14.2)		
Calsius 2015[25] D'hooghe 2014[37] Pre-post Hiking MS (n=5)					Fatigue - FSMC total, median (range) Pre: 68 (23-79) End of training: 61 (24-79) Post hiking trip: 59 (27-82) Follow-up: 69 (26-84) Transient reduction in fatigue	No comparator group

Author, year Design Sport Population (n enrolled)	Health		Balance		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Earles 2015[38] Pre-post Equine-assisted therapy Anxiety/PTSD (n=16)	PHQ Somatic Symptoms, mean (SD) Pre: 7.9 (3.3) Post: 7.1 (3.1) ES=0.37, P NS	No comparator group			AUDIT-C, mean (SD) Pre: 3.3 (2.6) Post: 2.6 (2.1) ES=0.58, P<.05	No comparator group
Hammer 2005[49] Pre-post Hippotherapy MS (n=13)	SF-36 General Health 4 of 11 participants had positive score change ≥15 from pre-intervention 2 of 11 had negative score change ≥15	No comparator group	BBS 3 of 11 participants had clinically significant change from pre-intervention Timed Up and Go 2 of 10 had clinically significant change from pre-intervention	No comparator group	SF-36 Pain 3 of 11 had positive score change ≥15 from pre-intervention 1 of 11 had negative score change ≥15 Visual Analog Pain No participants showed clinically significant change in pain from pre-intervention	No comparator group
Herzog 2018[54] RCT (cross-over) Wheelchair curling SCI (n=13)			MFRT, medians, cm *Forward* Pre: 29.3 Post: 32.7 P=.22 *Sideward* Pre: 16.3 Post: 19.3 P=.06	No comparator group (groups combined due to no carry-over effect)		
Jolk 2015[59] Pre-post case series Sports Climbing			Postural Sway, mean (SD) Pre: 4.8 (0.8) Post: 4.3 (0.9)	No comparator group		

Author, year Design Sport Population (n enrolled)	Health		Balance		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
MS (n=7)			P=.12 NOTE: score of 4-5 corresponds to healthy controls			
Lanning 2013[64] Pre-post Equine-assisted activity Mental/physical wounds (n=13)	SF-36 General Health Reported increase in group mean scores over 12 weeks (n=13) and 24 weeks (n=7 completers)	No comparator group				
Lindroth 2015[67] Pre-post Hippotherapy MS (n=3)			BBS 3 of 3 participants improved scores by 2 to 6 points over 6-week training; all continued improvement at 6-week follow-up	No comparator group		
Muñoz-Lasa 2011[80] Pre-post with comparator (CCT) Therapeutic horseback riding MS (n=27)			*Riding + Physiotherapy* POMA, mean (SD) Pre: 15.5 (6.9) Post: 19.4 (3.5) P<.005	*Physiotherapy* POMA, mean (SD) Pre: 17.2 (6.6) Post: 17.6 (6.5)		
Schachten 2015[96] CCT (matched pairs) Golf CVA (n=14)			*Golf training* BBS, mean (SD) Pre: 46.9 (15.9) Post: 50.7 (11.2) ES=0.26, P NS	*Social communication* BBS, mean (SD) Pre: 21.0 (21.7) Post: 23.7 (24.6)	*Golf training* Block Tapping Test (visual-spatial short-term memory), mean (SD) Pre: 3.3 (1.9)	*Social communication* Block Tapping Test (visual-spatial short-term memory), mean (SD)

Author, year Design Sport Population (n enrolled)	Health		Balance		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
					Pre: 4.7 (1.1) Post: 6.1 (0.9) ES=0.95, P<.05	Post: 3.6 (1.9)
Shatil 2005[97] RCT Golf CVA (n=18)			*Therapeutic golf* BBS, mean (SD) Pre: 46.6 (8.6) Post: 49.8 (8.5) P=.0003 CMPCI, mean (SD) Pre: 4.6 (0.7) Post: 5.5 (1.0) P=.01	*Hand therapy* BBS, mean (SD) Pre: 43.8 (12.3) Post: 44.9 (13.1) CMPCI, mean (SD) Pre: 4.9 (1.1) Post: 4.9 (1.1)		
Silkwood-Sherer[99] 2007 CCT Hippotherapy MS (n=15)			*Hippotherapy* BBS, median Pre: 35.0 Post: 55.0 P<.05 (post-test) POMA, median Pre: 17.0 Post: 27.0 P=.08	*Wait list* BBS, median Pre: 41.5 Post: 41.0 POMA, median Pre: 19.0 Post: 19.0		
Velikonja 2010[112] RCT Sports Climbing MS (n=20)					*Sports climbing* Executive Function, median a. NAB – Mazes Pre: 14.0 Post: 16.0 P=.34 from pre P NS between groups b. Tower of London (number of moves) Pre: 34 Post: 26	*Yoga* Executive Function, median a. NAB – Mazes Pre: 20.5 Post: 19.0 P=.44 from pre b. Tower of London (number of moves) Pre: 23 Post: 33

Author, year Design Sport Population (n enrolled)	Health		Balance		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
					P=.17 from pre P NS between groups Fatigue – MFIS total Pre: 40.0 Post: 27.0 P=.02 from pre P between groups NR	P=.06 from pre Fatigue – MFIS total Pre: 32.0 Post: 23.0 P=.06 from pre
Vella 2013[113] Pre-post Fly-fishing PTSD (n=74)					PSQI, mean (SD) Pre: 13.1 (3.6) 6-week follow-up: 11.6 (3.9) P<.001	No comparator group
Vermöhlen 2017[114] RCT Hippotherapy MS (n=70)			*Hippotherapy* BBS, mean (SD) Pre: 40.6 (11.5) Post: 47.0 (8.7) Mean change: 6.4 (5.4) Difference between groups at 12 weeks: 2.33 (95%CI 0.03, 4.63), P=.047	*Usual care* BBS, mean (SD) Pre: 42.1 (10.9) Post: 45.1 (10.9) Mean change: 3.1 (5.1)	*Hippotherapy* Visual Analog Pain, mean (SD) Pre: 32.3 (29.9) Post: 24.9 (27.6) Mean change: -7.4 (16.8) Difference between groups at 12 weeks: -3.1 (95%CI -13.4, 7.3), P=.56 Fatigue – FSS, mean (SD) Pre: 51.8 (10.5) Post: 42.6 (11.4) Mean change: -9.2 (10.3) Difference between groups at 12	*Usual care* Visual Analog Pain, mean (SD) Pre: 24.7 (29.3) Post: 23.4 (27.0) Mean change: -1.3 (28.0) Fatigue – FSS, mean (SD) Pre: 47.8 (11.9) Post: 46.8 (10.6) Mean change: -0.9 (8.4)

Author, year Design Sport Population (n enrolled)	Health		Balance		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
					weeks: -6.8 (95%CI -11.0, -2.6), P=.002	
Zoerink 2015[119] Pre-post Golf CVA (n=11)			BBS, mean, sec a. Sit-stand Pre: 32.2 Post: 34.0 P=.38 b. 1-foot stand Pre: 26.9 Post: 24.0 P=.002 NOTE: authors report improved 1-foot stand but data show less time standing	No comparator group		
SPORTS ACTIVITY PARTICIPATION STUDIES						
Aydoğ 2006[7] Cross-sectional with comparator Goalball Visual impairment (n=40)			*Goalball* Dynamic Postural Stability (overall index) 6.2 (1.9) P NS	*Blind sedentary* Dynamic Postural Stability (overall index) 8.1 (4.7)		
Aytar 2012[8] Case series Soccer Limb amputation (n=11)			Static Balance, mean (SD) 319.00 (120.41)	No comparator group		

Author, year Design Sport Population (n enrolled)	Health		Balance		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Campayo-Piernas 2017[26] Cross-sectional with comparator Soccer Visual impairment (n=22)			*Blind soccer players* Balance (resultant distance of center of pressure displacement, mm), mean (SD) Pre: 45.5 (17.0) Post: 33.6 (7.2) P NS	*Sighted soccer players* Balance (resultant distance of center of pressure displacement, mm), mean (SD) Pre: 44.5 (13.4) Post: 32.0 (5.6)		
Côté-Leclerc 2017[33] Mixed methods with comparator Multiple Mobility limitations (n=34)	*Paraplegia* QLI Health and Functioning, mean (SD) 21.9 (4.1) P=.71 between groups Not clinically significant (defined as ≥3-point difference)	*General population* QLI Health and Functioning, mean (SD) 22.4 (3.2)				
da Silva 2018[35] Cross-sectional with comparator Football (soccer) and goalball) Visual impairment (n=24)			*Players with blindness* Static Balance (s), mean (SD) 42.0 (17.0) P=.04	*Physically active, sighted* Static Balance (s), mean (SD) 45.0 (0.0)	*Players with blindness* FES-I, mean (SD) 22.6 (3.4) P=.01	*Physically active, sighted* FES-I, mean (SD) 17.5 (3.0)
Garshick 2016[45] Cross-sectional with comparator Multiple SCI (n=347)					Dyspnea OR 0.61 (95%CI 0.33, 1.12) Participation in	

Author, year Design Sport Population (n enrolled)	Health		Balance		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
					organized sports vs no participation	
Perrier 2015[87] Perrier 2012[86] Cross-sectional with comparator Multiple Multiple (largely SCI) (n=201)	*Involved in adaptive sport* Perceived risk of chronic disease, mean (SD) 12.1 (5.0) ES=.42, P NS	*Not Involved in adaptive sport* Perceived risk of chronic disease, mean (SD) 14.5 (6.1)				

Abbreviations follow Table 9.

Appendix D Table 4. Daily Functioning Outcomes – KQ1

Author, year Design Sport Population (n enrolled)	Activities of Daily Living		Gait		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
PROGRAM STUDIES						
Beinotti 2013[11] RCT Therapeutic horseback riding CVA (n=24)					*Riding + Conventional therapy* SF-36 Functional Capacity, mean (SD) Pre: 40.5 (15.7) Post: 51.5 (14.3) P=.02	*Conventional therapy* SF-36 Functional Capacity, mean (SD) Pre: 50.0 (19.7) Post: 40.0 (26.0)
Beinotti 2010[12] CCT Hippotherapy CVA (n=20)			*Riding + Conventional therapy* FAC, mean (SD) Pre: 3.6 (0.8) Post: 3.8 (0.9) P=.93	*Conventional therapy* FAC, mean (SD) Pre: 3.2 (1.0) Post: 3.4 (1.0)		
Bennett 2017[14] Pre-post Fly-fishing Combat-related disabilities (n=40)					WRFIS, mean (SD) Pre: 35.7 (13.6) Post: 31.2 (10.9) 3-month follow-up: 35.2 (13.3) P≤.005 (Pre vs Post) P NS (Pre vs Follow-up)	No comparator group
Calsius 2015[25] D'hooghe 2014[37] Pre-post Hiking MS (n=5)			MSWS-12, median (range) Pre: 14 (12-39) End of training: 13 (12-26)	No comparator group		

Author, year Design Sport Population (n enrolled)	Activities of Daily Living		Gait		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
			Post hiking trip: 13 (12-31) Follow-up: 14 (12-38) P NS over time			
Hammer 2005[49] Pre-post Hippotherapy MS (n=13)	PSFS 4 of 9 participants had clinically significant positive change from pre-intervention on at least 1 ADL; none had clinically significant negative change	No comparator group	Gait velocity - 10 meter walking test m/s 0 of 10 had clinically significant change from pre-intervention to post-intervention; 1 of 10 had clinically significant change at 3-week follow-up	No comparator group		
Herzog 2018[54] RCT (cross-over) Wheelchair curling SCI (n=13)	*Training* SCIM III No differences between groups at crossover (4 weeks) or final assessment (8 weeks)	*Non-training*				
Lanning 2013[64] Pre-post Equine-assisted activity Mental/physical wounds (n=13)					SF-36 Physical Functioning Reported no change in group mean scores over 12 weeks (n=13); increase over 24 weeks (n=7 completers)	No comparator group

Author, year Design Sport Population (n enrolled)	Activities of Daily Living		Gait		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Lindroth 2015[67] Pre-post Hippotherapy MS (n=3)			FGA 3 of 3 participants improved scores by 2 to 6 points over 6-week training; no to little change at 6 week follow-up	No comparator group		
Muñoz-Lasa 2011[80] Pre-post with comparator (CCT) Therapeutic horseback riding MS (n=27)	*Riding + Physiotherapy* BI, mean (SD) Pre: 89.6 (10.5) Post: 90.4 (8.9) P NS	*Physiotherapy* BI, mean (SD) Pre: 90.3 (10.9) Post: 90.7 (11.3)				
Zoerink 2015[119] Pre-post Golf CVA (n=11)			FFB agility, mean, sec Pre: 18.3 Post: 16.5 P=.16	No comparator group		
SPORTS ACTIVITY PARTICIPATION STUDIES						
da Silva 2015[35] Cross-sectional with comparator Multiple Visual Impairment (n=24)			*Goalball or football with blindness* Self-selected Walking Speed (m/s), mean (SD) 1.3 (0.3) P=.08	*Physically active, sighted* Self-selected Walking Speed (m/s), mean (SD) 1.4 (0.2)		
Hanson 2001[50]Cross-sectional Multiple SCI (n=48)					*Athletes* CHART Physical Independence, mean (SD) 95.3 (8.8) P=.006	*Non-athletes* CHART Physical Independence, mean (SD) 78.3 (33.3)

Author, year Design Sport Population (n enrolled)	Activities of Daily Living		Gait		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Miki 2012[77] Cross-sectional Wheelchair basketball SCI (n=82)	SCIM (Japanese version) Score <65: 44% (36/82) Score over 65: 48% (39/82) Not reported: 9% (7/82)	No comparator group				
Sporner 2009[103] Cross-sectional Multiple Multiple (n=132)					CHART Physical Independence, mean (SD) 69.1 (43.2)	No comparator group

Abbreviations follow Table 9.

Appendix D Table 5. Self-Esteem/Perceived Competence – KQ1

Author, year Design Sport Population (n enrolled)	Self-Esteem		Perceived Competence		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
PROGRAM STUDIES						
Barbin 2008[9] Pre-post Skiing SCI (n=10)	PSI-6, mean (SD) Global self-esteem Pre: 6.4 (1.4) Post: 7.1 (1.6) P<.05	No comparator group			PSI-6, mean (SD) *Physical self-worth* Pre: 6.0 (1.5) Post: 6.9 (1.7) P<.001 *Sport Competence* Pre: 5.6 (1.2) Post: 6.9 (1.5) P<.01	No comparator group
Bennett 2017[14] Pre-post Fly-fishing Combat-related disabilities (n=40)			BNSLS, mean (SD) Pre: 99.3 (18.3) Post: 102.5 (20.9) 3-month follow-up: 101.4 (20.2) P NS	No comparator group		
Calsius 2015[25] D'hooghe 2014[37] Pre-post Hiking MS (n=5)					ESES, median (range) Pre: 36 (27-40) End of training: 37 (33-40) Post hiking trip: 37 (33-40) Follow-up: 37 (28-39) P NS over time	No comparator group
Earles 2015[38] Pre-post Equine-assisted therapy					GPSES, mean (SD) Pre: 28.6 (7.6) Post: 30.2 (5.8) ES=0.45, P NS	No comparator group

Author, year Design Sport Population (n enrolled)	Self-Esteem		Perceived Competence		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Anxiety/PTSD (n=16)						
Lundberg 2011[70] Pre-post Water sports, fly-fishing, winter sports Post-combat disability (n=18)			PCS, mean (SD) Pre: 16.3 (6.1) Post: 21.7 (5.5) P=.001	No comparator group		
SPORTS ACTIVITY PARTICIPATION STUDIES						
Adnan 2001[3] Cross-sectional Quad rugby Quadriplegia (n=30)					*Participants* SEADL Participants scored significantly higher on 5 of 28 activities of daily living; all items related to transferring ES=0.92 to 1.23	*Non-participants* SEADL
Laferrier 2015[63] Cross-sectional Multiple Multiple (n=220)	RSES, mean (SD) Overall: 24.0 (3.5) >10 years participation in sport/exercise/ recreation: 26.9 (SE 1.1)* 5-10 years: NR** 1-5 years: 22.9 (SE 0.6) <1 year: 21.6 (SE 0.6)	No comparator group				

Author, year Design Sport Population (n enrolled)	Self-Esteem		Perceived Competence		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
	*P<.001 vs 1-5 yrs and <1 year **P=.02 vs <1 year Team sports: 22.3 (SE 1.1) Individual sports: 25.3 (SE 1.0)*** Combination: 25.1 (SE 0.7) ***P<.05 vs team or combination					
Perrier 2015[87] Perrier 2012[86] Cross-sectional with comparator Multiple Multiple (largely SCI) (n=201)					*Involved in adaptive sport* TEOSQ Task Self-efficacy, mean (SD) 40.8 (13.8) ES=1.34 Barrier Self-efficacy, mean (SD) 46.6 (14.6) ES=1.58	*Not Involved in adaptive sport* TEOSQ Task Self-efficacy, mean (SD) 21.3 (15.1) Barrier Self-efficacy, mean (SD) 24.9 (13.1)
Scarpa 2011[95] Cross-sectional Multiple Paraplegia (n=143)	*Physical disabled practicing sport* PSDQ Global Esteem, mean (SD) 4.9 (0.7) P<.001 (calculated)	*Physical disabled not practicing sport* PSDQ Global Esteem, mean (SD) 4.0 (1.3)			*Physical disabled practicing sport* PSDQ Global Physical, mean (SD) 4.4 (1.2) P=.004 (calculated)	*Physical disabled not practicing sport* PSDQ Global Physical, mean (SD) 3.7 (1.3)

Author, year Design Sport Population (n enrolled)	Self-Esteem		Perceived Competence		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Skordilis 2001[101] Cross-sectional Multiple Multiple (n=243)					TEOSQ, mean SD *Task Orientation:* 4.3 (0.5) *Ego Orientation:* 2.7 (0.8) NOTE: wheelchair marathoners scored higher (P=.001) than wheelchair basketball players on Ego orientation; no gender differences or interaction	No comparator group
Skučas 2013[102] Cross-sectional Multiple Tetraplegic or paraplegic (n=106)					AIMS, mean Paraplegic: 23 Tetraplegic: 18 P<.05 Male: 22 Female: 16 P<.05 Overall 10.6% had scores of 28 points (“athletic identity”) More hours/week of participation associated with higher athletic identity (data NR)	No comparator group
Sporner 2009[103] Cross-sectional Multiple Multiple (n=132)	RSES, mean (SD) 34.3 (5.5)	No comparator group				

Author, year Design Sport Population (n enrolled)	Self-Esteem		Perceived Competence		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Tasiemski 2004[106] Tasiemski 2005[107] Cross-sectional Multiple SCI (n=985)					AIMS, mean (SD) 16.5 (9.9) Male: 17.3 (10.1) Female: 12.4 (10.1) P<.01 Sports participation (hours/week) 6+: 26.9 (11.0) 3 to <6: 19.9 (9.7) 1 to <3: 16.2 (8.0) <1: 14.9 (8.9) None: 11.6 (7.2) P<.01 for all comparisons No gender X hours/week interaction	No comparator group
Tasiemski 2011[105] Cross-sectional Multiple SCI (n=1034)					AIMS, mean (SD) 20.6 (11.7) Age, gender, and current amount of sports participation per week were significant predictors of athletic identity (higher identity scores for younger, male, and higher self-reported activity) Those able to practice their favorite sport after	No comparator group

Author, year Design Sport Population (n enrolled)	Self-Esteem		Perceived Competence		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
					SCI had higher AIMS scores (P<.001) No significant difference in AIMS scores for team vs individual sports	
Tasiemski 2012[108] Cross-sectional Tandem Cycling Visual Impairment (n=50)					*Visually impaired* AIMS, mean (range) 24.8 (7-49) P<.01 *Time when vision failed* From birth: 24.5 (8.5) Later in life: 25.1 (7.6) P NS *Hours per week training* 9-12: 21.6 (4.5) 13-16: 26.4 (8.8) P NS	"*Able-bodied*" AIMS, mean (range) 36.4 (7-49)

Abbreviations follow Table 9.

Appendix D Table 6. Mental Health (Mood, Depression, Anxiety, PTSD) Outcomes

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
PROGRAM STUDIES								
Beinotti 2013[11] RCT Therapeutic horseback riding CVA (n=24)	*Riding + Conventional therapy* SF-36 Mental Health, mean (SD) Pre: 73.2 (22.5) Post: 83.2 (16.9) P=.04	*Conventional therapy* SF-36 Mental Health, mean (SD) Pre: 72.4 (13.7) Post: 68.8 (18.5)						
Bennett 2017[14] Pre-post Fly-fishing Combat-related disabilities (n=40)			PCL-M, mean (SD) Pre: 51.1 (17.8) Post: 39.3 (14.4)* 3-month follow-up: 46.7 (16.9) *P<.05 pre to post	No comparator group	PHQ-9, mean (SD) Pre: 20.9 (6.7) Post: 15.9 (6.0)* 3-month follow-up: 19.8 (6.9) *P<.05 pre to post	No comparator group		
Bennett 2014[13] CCT Ski/snowboard PTSD (n=34)			*Group A: Higher Ground program* *Group B: Same with added communication training*	*No program*				

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
			PCL-M/C, mean (SD) Post-intervention A: 34.6 (9.5) B: 41.8 (19.3) Difference from pre, mean (SE) A: -15.6 (4.2)*^ B: -9.2 (3.9)* *P<.05 vs pre ^P<.05 vs control	PCL-M/C, mean (SD) Post-intervention 49.4 (21.6) Difference from pre, mean (SE) 1.19 (3.9)				
Earles 2015[38] Pre-post Equine-assisted therapy Anxiety/PTSD (n=16)			PCL-S, mean (SD) Pre: 50.9 (12.6) Post: 39.4 (16.7) ES=1.21, P<.001	No comparator group	PHQ-9, mean (SD) Pre: 20.5 (7.5) Post: 18.3 (6.3) ES=0.54, P<.05 GAD, mean (SD) Pre: 12.6 (6.2) Post: 8.3 (5.5) ES=1.01, P<.01	No comparator group		
Hammer 2005[49] Pre-post Hippotherapy MS (n=13)	SF-36 Mental Health 3 of 11 participants had positive score change ≥15 from pre-intervention	No comparator group						

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
	2 of 11 had negative score change ≥15							
Johnson 2018[58] RCT Therapeutic horseback riding PTSD (29)			*Therapeutic riding* PCL-M, mean (SD) Pre: 57.7 (14.6) 3 weeks: 53.2 (13.8) 6 weeks: 47.0 (14.7) (includes riding group plus wait list group when enrolled in riding program) P<.05 for week 3 vs Pre and week 6 vs week 3	*Wait list* PCL-M, mean (SD) Pre: 58.4 (16.4) 3 weeks: 57.6 (13.2) 6 weeks: 59.2 (14.3)				
Lanning 2013[64] Pre-post Equine-assisted activity Mental/physical wounds (n=13)	SF-36 Mental Health Reported increase in group mean scores over 12 weeks (n=13); and 24 weeks (n=7 completers)	No comparator group			BDI-II Reported decreased depressive symptoms over 12 weeks (n=13) and 24 weeks (n=7 completers) but remaining in moderate	No comparator group		

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
					depression range			
Lundberg 2011[70] Pre-post Water sports, fly-fishing, winter sports Post-combat disability (n=18)							POMS-Brief, mean (SD) Pre: 60.4 (24.0) Post: 33.7 (16.9) P<.001	No comparator group
Malinowski 2017[75] Pre-post Equine-assisted therapy PTSD (n=7)	BSI, mean (SE) Pre: 65.4 (2.7) Post: 54.1 (3.2) P=.003	No comparator group	PCL-5, mean (SE) Pre: 59.4 (3.9) Post: 48.6 (3.7) P=.049	No comparator group				
Rogers 2014[93] Pre-post Ocean Therapy PTSD (n=14, 11 completers)			PCL-M, median Pre: 55 Post: 34 Median of differences: 18.2, P<.0005 ES=.77 Clinically subthreshold PTSD symptoms: Pre: 9% (1/11) Post: 73% (8/11)	No comparator group	MDI, median Pre: 33 Post: 14 Median of differences: 11.3, P=.03 ES=.61 Severe depression Pre: 36% (4/11) Post: 18% (2/11)	No comparator group		

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Schachten 2015[96] CCT (matched pairs) Golf CVA (n=14)					*Golf training* CES-D, mean (SD) Pre: 5.6 (3.4) Post: 1.6 (2.0) ES=0.31, P NS	*Social communication* CES-D, mean (SD) Pre: 9.1 (9.5) Post: 6.7 (8.5)		
Velikonja 2010[112] RCT Sports Climbing MS (n=20)					*Sports climbing* CES-D, median Pre: 10.0 Post: 5.0 P=.68 from pre	*Yoga* CES-D, median Pre: 9.5 Post: 3.0 P=.21 from pre		
Vella 2013[113] Pre-post Fly-fishing PTSD (n=74)	BSI, mean (SD) Pre: 28.1 (13.5) Last day: 11.4 (10.3) 6-week follow-up: 18.4 (12.4) P<.001 for baseline vs other times	No comparator group	PCL-M, mean (SD) Pre: 59.4 (13.6) 6-week follow-up: 49.6 (15.1) P<.001	No comparator group			PANAS Negative Affect, mean (SD) Pre: 26.6 (7.9) Last day: 16.3 (6.8) 6-week follow-up: 22.5 (7.4) P<.001 for baseline vs other times PANAS Positive Affect, mean (SD) Pre: 25.6 (7.2) Last day: 36.4 (7.7)	

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
							6-week follow-up: 26.9 (7.7) P<.001 for baseline vs last day	
SPORTS ACTIVITY PARTICIPATION STUDIES								
Bauerfeind 2015[10] Longitudinal case series Wheelchair rugby Tetraplegia (n=14)							CAAS, mean (SD) Offensive players: 81.7 (11.9) Defensive players: 73.0 (8.6) P=.19 CAAS not associated with incidence of sports injuries not requiring medical intervention	No comparator group
Fiorilli 2013[42] Cross-sectional Wheelchair basketball SCI or Limb amputation (n=46)	*Participants* SCL-90-R mean (SD) 0.34 (0.31) P=.008	*Non-participants* SCL-90-R, mean (SD) 0.61 (0.31)						

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Foreman 1997[43] Cross-sectional Multiple Paraplegia or quadriplegia (n=121)					*Participants* CES-D, mean (SD) 11.9 (10.5) P=.10 STAI-trait, mean (SD) 36.8 (10.7) P=.048	*Non-participants* CES-D, mean (SD) 13.0 (10.7) STAI-trait, mean (SD) 40.5 (9.8)		
Muraki 2000[81] Cross-sectional Multiple Tetraplegia or paraplegia (n=169)					*High active* SDS, mean (SD) Tetra: 38.2 (2.9) Para: 38.4 (7.0) No difference between Tetra and Para; P<.05 for high active vs inactive, high active vs low active, and middle active vs inactive (all data not shown) STAI state, mean (SD) Tetra: 39.7 (6.5) Para: 39.0 (6.8) No difference between Tetra	*Inactive* SDS, mean (SD) Tetra: 46.4 (7.1) Para: 47.4 (7.4) No difference between Tetra and Para STAI state, mean (SD) Tetra: 44.2 (9.0) Para: 45.6 (9.4)	POMS No differences on any POMS subscale between tetraplegia and paraplegia POMS Depression: Lower scores for high active vs inactive and high active vs low active, P<.05 POMS Vigor: Higher scores for high active vs inactive, low active, or middle active and middle active vs inactive, P<.05 No differences on other POMS subscales NOTE: no differences in SDS, STAI, or POMS outcomes across sports (basketball, racing, tennis, or "minor" modes) despite	

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
					and Para; P NS for high active vs inactive STAI trait, mean (SD) Tetra: 37.6 (11.9) Para: 37.7 (7.2) No difference between Tetra and Para; P<.05 for high active vs inactive	No difference between Tetra and Para STAI trait, mean (SD) Tetra: 45.1 (10.1) Para: 44.8 (11.3) No difference between Tetra and Para	differences in intensity, frequency (days/week), or duration (min/day) for the sports	
Silveira 2017[100] Cross-sectional Wheelchair rugby Tetraplegia (n=150)					CES-D, mean (SD) 5.6 (4.4) 17% (26/150) scored 10 or higher (further assessment for clinical depression recommended) *Practice frequency* ≤1/week: 6.5 (4.8) ≥2/week: 5.2 (4.0) P<.10	No comparator group		
Tasiemski 2004[106] Tasiemski 2005[107]					HADS anxiety, mean (SD) 6.9 (4.2)	No comparator group		

Author, year Design Sport Population (n enrolled)	Mental Health		PTSD Symptoms		Depression/Anxiety		Mood/Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Cross-sectional Multiple SCI (n=985)					HADS depression, mean (SD) 5.5 (3.7)			
Tasiemski 2011[105] Cross-sectional Multiple SCI (n=1034)					HADS-Depression, mean (SD) 13.2 (4.0) Those able to practice their favorite sport after SCI had lower depression scores (P<.001) Team sports participants had lower depression scores (P<.05) HADS-Anxiety, mean (SD) 14.2 (4.1) Team sports participants had lower anxiety (P<.005)	No comparator group		

Abbreviations follow Table 9.

Appendix D Table 7. Quality of Life

Author, year Design Sport Population (n enrolled)	Health-Related Quality of Life		Satisfaction with Life		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
PROGRAM STUDIES						
Beinotti 2013[11] RCT Therapeutic horseback riding CVA (n=24)	*Riding + Conventional therapy* SF-36 Total, mean Pre: 77.0 Post: 93.6 P=.004	*Conventional therapy* SF-36 Total, mean Pre: 79.6 Post: 73.5				
Bennett 2017[14] Pre-post Fly-fishing Combat-related disabilities (n=40)					LSS, mean (SD) Pre: 48.6 (17.9) Post: 52.0 (7.6) 3 month follow-up: 53.7 (14.7) P=.08 pre- to follow-up	No comparator group
Bennett 2014[13] CCT Ski/snowboard PTSD (n=34)					*Group A: Higher Ground program* *Group B: Same with added communication training* RDAS, mean (SD) Post-intervention A: 45.5 (6.5) B: 41.2 (6.8) Difference from pre, mean (SE) A: 0.6 (1.4) B: 3.9 (1.3)* *P<.05 vs pre	*No program* RDAS, mean (SD) Post-intervention 45.6 (12.6) Difference from pre, mean (SE) 2.4 (1.3)

Author, year Design Sport Population (n enrolled)	Health-Related Quality of Life		Satisfaction with Life		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
					P=.25 between groups	
Earles 2015[38] Pre-post Equine-assisted therapy Anxiety/PTSD (n=16)			SWLS, mean (SD) Pre: 17.8 (6.1) Post: 19.1 (7.7) ES=0.25, P NS	No comparator group		
Lundberg 2011[70] Pre-post Water sports, fly-fishing, winter sports Post-combat disability (n=18)					WHOQoL-BREF, mean (SD) Pre: 74.4 (15.0) Post: 78.8 (13.9) P=.004	No comparator group
Shatil 2005[97] RCT Golf CVA (n=18)			*Therapeutic golf* SIP, mean (SD) Pre: 26.2 (14.3) Post: 18.1 (12.5) P=.04 (for change between groups)	*Hand therapy* SIP, mean (SD) Pre: 27.9 (6.3) Post: 23.9 (12.6)		
Vermöhlen 2017[114] RCT Hippotherapy MS (n=70)	*Hippotherapy* MSQoL-54, mean (SD) *Physical Health* Pre: 46.0 (14.2) Post: 57.0 (15.1) Mean change: 11.0 (12.0) Difference between groups at 12 weeks: 12.0	*Usual care* MSQoL-54, mean (SD) *Physical Health* Pre: 53.7 (14.6) Post: 51.3 (15.9) Mean change: -2.4 (9.3)				

Author, year Design Sport Population (n enrolled)	Health-Related Quality of Life		Satisfaction with Life		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
	(95%CI 6.2, 17.7), P<.001 *Mental Health* Pre: 62.6 (18.0) Post: 75.7 (15.0) Mean change: 13.1 (15.2) Difference between groups at 12 weeks: 14.4 (95%CI 7.5, 21.3), P<.001	*Mental Health* Pre: 67.1 (17.2) Post: 64.2 (19.9) Mean change: -2.9 (14.8)				
SPORTS ACTIVITY PARTICIPATION STUDIES						
Aytar 2012[8] Case series Soccer Limb amputation (n=11)	ODI, mean (SD) 5.3 (6.7)	No comparator group				
Côté-Leclerc 2017[33] Mixed methods with comparator Multiple Mobility limitations (n=34)			*Paraplegia* QLI Total, mean (SD) 21.9 (3.3) P=.64 between groups; "good" quality of life Not clinically significant (defined as ≥3-point difference)	*General population* QLI Total, mean (SD) 22.3 (2.9)		
Garshick 2016[45] Cross-sectional with comparator Multiple			*Participation in organized sports* SWLS, mean (95%CI)	*No participation* SWLS, mean (95%CI)		

Author, year Design Sport Population (n enrolled)	Health-Related Quality of Life		Satisfaction with Life		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
SCI (n=347)			25.6 (23.9, 27.3) P=.009 Participation in organized sports vs no participation	23.0 (22.2, 23.9)		
Laferrier 2015[63] Cross-sectional Multiple Multiple (n=221)					WHOQoL-BREF Scores not reported Positive relationship between overall quality of life and number of years participating in sport, exercise, recreation since onset of disability (P<.001) No significant relationship between type of activity (team, individual, combination) and quality of life	No comparator group
McVeigh 2009[76] Cross-sectional Multiple Tetraplegia or paraplegia (n=90)					*Sport participant* RNL, mean (SD) 100.2 (10.2) P<.05 between groups	*Non-sport participant* RNL, mean (SD) 83.6 (18.0)
Sporner 2009[103] Cross-sectional Multiple Multiple (n=132)					WHOOoL-BREF, mean (SD) 63.6 (9.1)	No comparator group

Author, year Design Sport Population (n enrolled)	Health-Related Quality of Life		Satisfaction with Life		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Tasiemski 2004[106] Tasiemski 2005 Cross-sectional Multiple SCI (n=985)			LiSat-9, mean (SD) 3.9 (1.0)	No comparator group		
Tasiemski 2011[105] Cross-sectional Multiple SCI (n=1034)			LiSat-9, mean (SD) 32.1 (8.8) Those able to practice their favorite sport after SCI had higher LiSat-9 scores (P<.001) Team sports participants had higher LiSAT-9 scores (P<.01)	No comparator group		
Yazicioglu 2012[117] Cross-sectional with comparator Multiple SCI or Limb amputation (n=60)			*Adaptive sport participants with physical disabilities* SWLS, mean (SD) 20.5 (7.8) P=.002	*Non-sport participants with physical disabilities* SWLS, mean (SD) 15.1 (6.9)	*Adaptive sport participants with physical disabilities* WHOQoL-BREF Reported significantly higher in sport participant group (P=.003)	*Non-sport participants with physical disabilities* WHOQoL-BREF
Zwierzchowska 2017[120] Cross-sectional with comparator Wheelchair rugby SCI (n=36)			*Low point or high point players* LiSat-9, mean Low point: 3.9 High point: 4.7 P NS	*Sedentary disabled* LiSat-9, mean 4.0		

Abbreviations follow Table 9.

Appendix D Table 8. Community Reintegration/Participation in Social Activities

Author, year Design Sport Population (n enrolled)	Community Reintegration		Social Functioning		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
PROGRAM STUDIES						
Beinotti 2013[11] RCT Therapeutic horseback riding CVA (n=24)			*Riding + Conventional therapy* SF-36 Social, mean (SD) Pre: 81.3 (19.3) Post: 90.0 (12.9) P=.53	*Conventional therapy* SF-36 Social, mean (SD) Pre: 48.8 (28.5) Post: 58.8 (36.8)		
Hammer 2005[49] Pre-post Hippotherapy MS (n=13)			SF-36 Social Functioning 3 of 11 participants had positive score change ≥15 from pre-intervention 3 of 11 had negative score change ≥15	No comparator group		

Author, year Design Sport Population (n enrolled)	Community Reintegration		Social Functioning		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Johnson 2018[58] RCT Therapeutic horseback riding PTSD (29)					*Therapeutic riding* SELSA, mean (SD) Pre: 50.4 (11.9) 3 weeks: 53.5 (13.7) 6 weeks: 57.0 (10.3) (includes riding group plus wait list group when enrolled in riding program) P=.33 between groups at 6 weeks (calculated)	*Wait list* SELSA, mean (SD) Pre: 49.4 (5.1) 3 weeks: 52.1 (12.5) 6 weeks: 53.6 (8.0) NOTE: unexpected, increased loneliness
Lanning 2013[64] Pre-post Equine-assisted activity Mental/physical wounds (n=13)			SF-36 Social Functioning Reported decrease in group mean scores over 12 weeks (n=13); no change over 24 weeks (n=7 completers)	No comparator group		

Author, year Design Sport Population (n enrolled)	Community Reintegration		Social Functioning		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
Wickham 2000[115] Pre-post Wheelchair sports SCI (n=24)					*Camp participants* LMS Social, mean (SD), pre-test minus post-test -5.0 (10.9) ES=-0.70 P=.12 LMS Stimulus-Avoidance, mean (SD), pre-test minus post-test 6.8 (10.0) ES=-1.07 P=.02	*Non-participants* LMS Social, mean (SD), pre-test minus post-test -0.9 (6.1) LMS Stimulus-Avoidance, mean (SD), pre-test minus post-test 2.3 (7.0)
SPORTS ACTIVITY PARTICIPATION STUDIES						
Fiorilli 2013[42] Cross-sectional Wheelchair basketball SCI or Limb amputation (n=46)					*Participants* PS, mean (SD) 7.2 (9.2) P<.01	*Non-participants* PS, mean (SD) 38.1 (23.7) Less social restriction in participant group
Hanson 2001[50]Cross-sectional Multiple SCI (n=48)			*Athletes* CHART Social Integration, mean (SD) 94.7 (12.1) P=.001	*Non-athletes* CHART Social Integration, mean (SD) 76.8 (20.4)		

Author, year Design Sport Population (n enrolled)	Community Reintegration		Social Functioning		Other	
	Intervention	Comparator	Intervention	Comparator	Intervention	Comparator
McVeigh 2009[76] Cross-sectional Multiple Tetraplegia or paraplegia (n=90)	*Sport participant* CIQ, mean (SD) 19.0 (3.2) P<.05 between groups	*Non-sport participant* CIQ, mean (SD) 14.1 (4.4)				
Sporner 2009[103] Cross-sectional Multiple Multiple (n=132)			CHART Social Integration, mean (SD) 92.4 (19.8)	No comparator group		
Urbański 2013[110] Cross-sectional Multiple SCI (n=30)	CIQ, mean (SD) Individual sports: 22.7 (3.2) Team sports: 22.3 (3.4) P NS No correlation between level of activity, time from injury, level of injury, or age and CIQ score	No comparator group				

Abbreviations follow Table 9.

Appendix D Table 9. Employment

Author, year Design Sport Population (n enrolled)	Employment
SPORTS ACTIVITY PARTICIPATION STUDIES	
Blauwet 2013[16] Cross-sectional Multiple SCI (n=149)	Participation in organized sports and employment (paid full time or part time, regularly volunteering) OR 2.04 (95%CI 0.98, 4.69); P=.06
Kim 2017[61] Cross-sectional Multiple Paraplegia or tetraplegia (n=302)	Working before attending NVWG: 28% (84/302) Working after NVWG: 16% (47/302) Volunteering before attending NVWG: 15% (45/302) Volunteering after NVWG: 20% (59/302) *Positive influence of NVWG on employment* a) among those currently working: RR 1.52 (95%CI 1.21, 1.92) b) among those currently volunteering: RR 1.77 (95%CI 1.45, 2.17)
Lastuka 2015[66] Cross-sectional Multiple Multiple (n=131)	Additional year of participating in adaptive sports is associated with increase in employment rate through the first 10 years of playing sports (P=.03); association weakens if playing adaptive sports up to 15 years and disappears if playing adaptive sports up to 20 years

ADL=activities of daily living; AIMS=Athletic Identity Measurement Scale; AUDIT-C=Alcohol Use Disorders Identification Test; BBS/BBT=Berg Balance Scale/Test; BI=Bartel Index; BDI=Beck Depression Inventory; BNSLS=Basic Needs Satisfaction in Life Scale; BSI=Brief symptom Inventory; BTT=Block-Tapping task; CES-D=Center for Epidemiologic Studies Depression Scale; CHART=Craig Handicap Assessment Reporting Technique; CIQ=Community Integration Questionnaire; CMPCI=Chedoke-McMaster Postural Control Inventory; CSES=Coping Self Efficacy Scale; CVA=cerebrovascular accident or stroke; DERS=Difficulties in Emotion Regulation Scale; EAAT=equine assisted activities and therapies; EDSS=Expanded Disability Status Scale; EMG=Electromyography; ES=effect size; ESES=Exercise Self-Efficacy Scale; FAC=Functional Ambulation Category Scale; FES-I=Falls Efficacy Scale – International; FFB=Functional Fitness Battery; smoking cessation, alcohol control); FGA=Functional Gait Assessment; FSMC=Fatigue Scale for Motor and Cognition; FSS=Fatigue Severity Scale; GAD=Generalized Anxiety Disorder Scale; GPSES=General Perceived Self-Efficacy Scale; HADS=Hospital Anxiety and Depression Scale; IMF=Index of Muscle Function; IPAQ = International Physical Activity Questionnaire; LAM=Leisure Attitude Measurement; LiSat-9= Life Satisfaction Questionnaire-9 item; LMS=Leisure Motivation Scale; LSS=Leisure Satisfaction Scale; MAS=Modified Ashworth Scale; MDI=Major Depression Inventory; MRT=Mental Rotation Test; MFISt=Modified Fatigue Impact Scale (total); MFRT=Modified Functional Reach Test; MS=multiple sclerosis; MSQoL-54=Multiple Sclerosis Quality of Life-54; MSWS=Multiple Sclerosis Walking Ability Scale; NAB=Mazes subtest of Executive module from the Neuropsychosocial assessment battery; NR=not reported; NS=not statistically significant; NVWG=National Veterans Wheelchair Games; OR=odds ratio; PANAS=Positive Affect and Negative Affect Schedule; PCL-C=PTSD Checklist-Civilian; PCL-M=PTSD Checklist-Military; PCL-S=PTSD Checklist-Specific;

PCL-5=PTSD checklist for Diagnostic and Statistical Manual of Mental Disorders (DSM-5); PCI=Proactive Coping Inventory; PCS=Perceived Competence Scale; PHQ=Patient Health Questionnaire; POMA=Performance Oriented Mobility Assessment; POMS(-B)=Profile of Mood States (-Brief); PS=Participation Scale; PSDQ=Physical Self-Description Questionnaire; PSFS=Patient-Specific Functional Scale; PSI-6=Physical Self Inventory; PSQI=Pittsburgh Sleep Quality Inventory; PSS=Perceived Stress Scale; PTGI=Posttraumatic Growth Inventory; PTSD=post-traumatic stress disorder; QLI=Quality of Life Index; RDAS=Revised Dyadic Adjustment Scale; RNL=Reintegration to Normal Living Index; RSES=Rosenberg Self-Esteem; SCI=spinal cord injury; SCIM=Spinal Cord Independence Measure; SCL-90-R=Symptom Checklist 90; SDS=self-rating depression scale; SEADL=Self-Efficacy for Activities of Daily Living; SELSA=Social and Emotional Loneliness Scale for Adults – short version; SF-36=Medical Outcomes Study Short Form; SIP=Sickness Impact Profile; SOQ=Sport Orientation Questionnaire; SOT=Sensory Organization Test; STAI=State-Trait Anxiety Inventory; SWLS-Satisfaction with Life Scale; TEOSQ=Task and Ego Orientation in Sport Questionnaire; TOLnm=Tower of London Test (number of moves);TOLtt=Tower of London Test (total time); TUG=timed up and go; WRFIS=Walter Reed Functional Impairment Scale; WSC=Winter Sports Clinic (Veterans); VAS=Visual Analog Scale; WHOQoL-BREF=World Health Organization Quality of Life-Brief; WUSPI=Wheelchair User’s Shoulder Pain Index

APPENDIX E. QUALITY CHARACTERISTICS

Appendix E Table 1. Quality Characteristics of Included Qualitative Studies

Author, year	Congruity between theory and research methods	Congruity between methodology and research questions	Statement locating researcher culturally or theoretically	Participants adequately represented	Evidence of ethical approval	Comments
Bennett 2014[15] n=28	Unclear	Yes	No	Yes	Yes	Program was 'theory-based,' but no further detail on the theory behind the program or research methods; focus groups
Braganca 2018[20] n=61	No	Yes	No	Yes	Yes	Refers to researcher expertise in developing recommendations, but does not describe researchers' backgrounds or beliefs/values; self-completed questionnaire
Bragaru 2013[23] n=26	Yes	Yes	No	Yes	Yes	States no formal ethical permission was needed; interviews
Carin-Levy 2007[29] n=3	Yes	Yes	No	Yes	Yes	First author participates in the sport (diving) but does not describe how values/beliefs may influence research; semi-structured telephone interview
Carless 2013[31] Carless 2014[30] n=11	Yes	Yes	Unclear	Yes	Yes	Doesn't include statement about researcher's beliefs/values but describes in detail how researcher was embedded in adaptive program (2014); in-person interview
Chard 2016[32] n=45	No	Yes	No	Yes	Yes	Telephone interview
Giacobbi 2008[46] n=26	Yes	Yes	No	Yes	Yes	Third author is adaptive sports coach but does not describe how values/beliefs may influence research; semi-structured interviews (3rd author did not conduct interviews)
Hawkins 2011[52] n=10	Yes	Yes	Unclear	No	Yes	Semi-structured interview questions; 3 researchers independently interpreted interview data; only 10 of 50 program participants agreed to be interviewed

Author, year	Congruity between theory and research methods	Congruity between methodology and research questions	Statement locating researcher culturally or theoretically	Participants adequately represented	Evidence of ethical approval	Comments
Lape 2017[65] n=17	Unclear	Yes	No	Yes	Yes	Used "thematic analysis… that does not rely on a particular theory or epistemology"; focus groups
Litchke 2012[68] n=5	No	Yes	No	Yes	Yes	Participants were "purposefully selected" (injured at approximately same time in their lives); semi-structured interview and field observation by investigator and research assistants
Littman 2017[69] n=27	No	Yes	No	Yes	Yes	Semi-structured interview
Mowatt 2011[79] n=67	Yes	No	No	Yes	Yes	Research questions not stated; a co-investigator also served as program staff; analysis of participant's letters
Stephens 2012[104] n=7	Yes	Yes	No	Yes	Yes	Clearly designed and described study; in-person interviews
Taylor 1996[109] n=3	Yes	Yes	No	Yes	No	Series of interviews; author practiced ethnographic interviewing techniques

NA=not applicable

Appendix E Table 2. Quality Characteristics of Included Experimental and Observational Studies

Author, year	Inclusion criteria clearly defined	Subjects and setting described in detail	Strategies to deal with confounding factors	Outcomes measured in valid and reliable way	Evidence of ethical approval	Comments (include questionnaire/survey response rate, if applicable)
Adnan 2001[3] n=30	No	Yes	No	No	No	"Selected" participants; study-created questionnaires; adjusted for age only; 41% response in rugby group; unknown response in non-participant group; self-completed assessments
Akbar 2015[4] n=296	Yes	Yes	Unclear	Yes	Yes	Unclear if accounted for other factors besides sports participation; had institutional approval and informed consent; blinded clinical assessment
Aydoğ 2006[7] n=40	Yes	Yes	NA	Yes	Yes	Informed consent; objective outcome measure
Aytar 2012[8] n=11	Yes	Yes	NA	Yes	Yes	Objective balance measure; unclear how disability was rated
Barbin 2008[9] n=10	No	No	No	Yes	Yes	Informed consent; limited demographic information; self-report (pre-post design)
Bauerfeind 2015[10] n=14	No	Yes	No	Yes	No	Injury registries; unclear how subjective outcome was assessed
Beinotti 2013[11] n=24	Yes	No	NA	Yes	Yes	RCT; limited demographic information; concealed allocation; surveys administered by researchers blinded to treatment allocation
Beinotti 2010[12] n=20	Yes	No	NA	Yes	Yes	Non-random allocation; surveys administered by therapist with no bonds to the research
Bennett 2017[14] n=40	No	Yes	NA	Yes	Yes	Pre-post design
Bennett 2014[13] n=34 (17 couples)	Yes	Yes	NA	Yes	No	Non-random allocation; self-report; couples completes questionnaires separately
Blauwet 2017 n=134[18]	Yes	Yes	Yes	Yes	No	Secondary analysis of participant data from program logs

Author, year	Inclusion criteria clearly defined	Subjects and setting described in detail	Strategies to deal with confounding factors	Outcomes measured in valid and reliable way	Evidence of ethical approval	Comments (include questionnaire/survey response rate, if applicable)
Blauwet 2013[16] n=149[19]	Yes	Yes	Yes	No	Yes	Study-created questionnaire (self-report); response rate unclear
Boninger 1996[19] n=12	No	Yes	Yes	Yes	Yes	Individuals were invited to participate in training camp so applicability to all wheelchair racers is unknown
Bragaru 2013[22] n=780	No	Yes	Yes	Unclear	NA	Secondary analysis of larger database (self-report questionnaire data; 34% response rate; stated no formal ethical permission was needed; participants signed consent form
Bragaru 2015[21] n=175	Yes	Yes	Yes	No	Yes	Questionnaire (self-report) not previously validated; 45% response rate
Calsius 2015[25] D'hooghe 2014[37] n=9	No	Yes	NA	Yes	Yes	Pre-post; self-report
Campayo-Piernas 2017[26] n=21	No	Yes	NA	Yes	Yes	Objective balance measure
Côté-Leclerc 2017[33] n=68	Only for athletes	Only for athletes	NA	Yes	Yes	Control group derived from previous study; matching was inadequate; self-completed assessments
Curtis 1999[34] n=46	No	Yes	No	Yes	Yes	48% response rate to survey; self-report
da Silva 2018[35] n=24	No	Yes	NA	Yes	Yes	Groups not matched; researchers administered outcome assessments (questionnaires and performance measures)
Earles 2015[38] n=16	No	Yes	NA	Yes	Yes	Pre-post design; consent form and questionnaires administered by research assistant with no role in the therapy
Fiorilli 2013[42] n=46	Yes	No	NA	Yes	Yes	Informed consent; 1 researcher administered all assessments
Foreman 1997[43] n=121	No	Yes	Yes	Yes	Yes	Informed consent; response rate 60%; self-completed assessments

Author, year	Inclusion criteria clearly defined	Subjects and setting described in detail	Strategies to deal with confounding factors	Outcomes measured in valid and reliable way	Evidence of ethical approval	Comments (include questionnaire/survey response rate, if applicable)
Fullerton 2003[44] n=257	No	No	Yes	No	Yes	Unclear what percentage of responders was identified using the different recruitment approaches; little demographic data; study-created survey; self-reported assessment
Garshick 2016[45] n=347	No	Yes	Yes	Yes	Yes	97% response rate; interview (89%) or self-completed questionnaires
Hammer 2005[49] n=11	Yes	Yes	NA	Yes	Yes	Pre-post design; objective and self-report outcomes
Hanson 2001[50] n=48	No	No	NA	Yes	No	100% completed assessments either by interview or in writing (self-completing)
Haykowsky 1999[53] n=11	Yes	No	NA	No	Yes	Retrospective data collection (recall), reported injury rates only
Herzog 2018[54] n=13	Yes	Yes	NA	Yes	Yes	RCT cross-over design; “randomized by an independent person”; blinded objective outcome assessment
Jaarsma 2014[55] n=648	No	No	Yes	No	Yes	Did not separate on-line responses from telephone interview responses; adapted a questionnaire developed for Paralympic athletes; 13% response rate
Jackson 1996[57] n=33	No	Yes	NA	Yes	Unclear	Clinical criteria for diagnosis; patients provided informed consent; self-completed questionnaire and clinical assessment
Johnson 2018[58] n=29	Yes	No	NA	Yes	Yes	RCT; randomized based on identification number to treatment or wait-list; wait-list group data included in final outcomes data following completion of program; limited demographic information
Jolk 2015[59] n=7	Yes	No	NA	Yes	Yes	Pre-post design; limited demographic information; objective outcome measure
Kars 2009[60] n=105	Yes	No	No	No	Yes	Study-created questionnaire (self-report via mail); 36% response rate

Author, year	Inclusion criteria clearly defined	Subjects and setting described in detail	Strategies to deal with confounding factors	Outcomes measured in valid and reliable way	Evidence of ethical approval	Comments (include questionnaire/survey response rate, if applicable)
Kim 2017[61] n=302	Yes	Yes	No	No	Yes	Study-created questionnaire (self-report); 53% response rate
Laferrier 2015[63] n=220	Yes	Yes	NA	Yes	Yes	Study-created questionnaire (self-report); authors established face validity and reliability
Lanning 2013[64] n=13	No	No	NA	Yes	Yes	Pre-post design; limited demographic information
Lastuka 2015[66] n=131	No	Yes	Yes	No	No	Study-created survey (unclear how data were collected); no formal pilot; response rate unclear
Lindroth 2015[67] n=3	Yes	Yes	NA	Yes	Yes	Pre-post
Lundberg 2011[70] n=18	No	No	NA	Yes	Yes	Pre-post; limited demographic information
Malinowki 2018 n=7	No	Yes	NA	Yes	Yes	Pre-post
McVeigh 2009[76] n=90	Yes	Yes	Yes	Yes	No	Verbal consent; telephone interview; 97% response rate
Miki 2012[77] n=81	No	Yes	Yes	Yes	Yes	Self-report; response rate not reported
Molik 2010[78] n=174	No	No	NA	Yes	Yes	Self-report questionnaire
Muñoz-Lasa 2011[80] n=27	Yes	No	NA	Yes	Yes	Non-random allocation; limited demographic information
Muraki 2000[81] n=169	No	No	NA	Yes	No	54% response rate; little demographic data
Nam 2016[82] n=62	Yes	Yes	No	No	Yes	Descriptive statistics only; study-created interview/questionnaire based on ICF
Nettleton 2017[83] n=32	Yes	Yes	No	Yes	Yes	Self-report; 82% follow-up rate for 1 questionnaire, 78% for second questionnaire

Author, year	Inclusion criteria clearly defined	Subjects and setting described in detail	Strategies to deal with confounding factors	Outcomes measured in valid and reliable way	Evidence of ethical approval	Comments (include questionnaire/survey response rate, if applicable)
O'Neill 2004[85] n=33	No	No	NA	No	No	Study-created questionnaire administered by telephone; also encouraged "free speech responses"; 85% response rate
Perrier 2015[87] Perrier 2012[86] n=201	Yes	Yes	NA	No	Yes	Study-created questionnaire; self-report; 93% response rate for 1st questionnaire; 87% response rate for 2nd questionnaire
Pluym 1997[89] n=44	No	Yes	NA	No	No	Study-created questionnaire; in-home interview by 2 interviewers; 96% response
Ponchillia 2002[90] n=159	No	Yes	No	Yes	No	Telephone survey of "selected" members; cross-sectional study likely not appropriate to answer research questions about *predictors* of athletes' participation and beliefs; study-created survey but authors established validity/reliability
Rauch 2014[92] n=505	Yes	Yes	Yes	No	No	Secondary analysis; 27% response rate to full survey; study-created survey
Rogers 2014[93] n=13	Yes	Yes	NA	Yes	Yes	Pre-post design
Sá 2012 n=24	No	No	NA	No	No	Study-created survey (self-report)
Scarpa 2011[95] n=143	No	No	Yes	Yes	No	Participants identified through many sources including open on-line; little demographic data; written consent; self-report; we included data from 2 groups: disabled practicing sport and disabled not practicing sport
Schachten 2015[96] n=14 (7 matched pairs)	No	No	NA	Yes	Yes	Pre-post with matched pairs assigned to intervention and control groups (assignment method not reported); limited demographic information
Shatil 2005[97] n=18	Yes	Yes	NA	Yes	Yes	RCT; randomized by selecting 1 of 2 cards (representing the 2 groups); blinded outcome assessment

Author, year	Inclusion criteria clearly defined	Subjects and setting described in detail	Strategies to deal with confounding factors	Outcomes measured in valid and reliable way	Evidence of ethical approval	Comments (include questionnaire/survey response rate, if applicable)
Silkwood-Sherer 2007[99] n=15	Yes	No	NA	Yes	Yes	Pre-post with non-randomized comparison group; limited demographic information; blinding of outcome assessment not reported
Silveira 2017[100] n=150	Yes	Yes	Yes	Yes	Yes	Self-report; response rate unknown (individuals at rugby events were invited to participate)
Skordilis 2001[101] n=243	No	No	No	Yes	Yes	27% response rate (mailed questionnaire); distributed questionnaires via coaches of sports clubs so little information on inclusion criteria; informed consent; little demographic data and limited adjustment for confounders
Skučas 2013[102] n=106	No	No	NA	Yes	No	Little information about participant identification or demographics; no information on response rate; unclear if self-report
Sporner 2009[103] n=132	Yes	Yes	Yes	Yes	Yes	Response rate unclear (included individuals who volunteered to participate)
Tasiemski 2004[106] Tasiemski 2005[107] n=28	Yes	No	No	Yes	Yes	Piloted questionnaire prior to study; self-report 56% response rate; unclear if demographic data for questionnaire completers or all participants
Tasiemski 2011[105] n=1034	Yes	Yes	No	Yes	Yes	59% response rate; self-report; limited consideration of potential confounders
Tasiemski 2012[108] n=50	No	Yes	NA	Yes	No	Little information on identification of study participants
Urbański 2013[110] n=28	No	Yes	NA	Yes	No	Telephone survey
Velikonja 2010[112] n=20	Yes	No	NA	Yes	Yes	RCT; allocation not reported; limited demographic information; blinded outcome assessment
Vella 2013[113]	Yes	Yes	NA	Yes	Yes	Pre-post design; on-line outcomes assessment

Author, year	Inclusion criteria clearly defined	Subjects and setting described in detail	Strategies to deal with confounding factors	Outcomes measured in valid and reliable way	Evidence of ethical approval	Comments (include questionnaire/survey response rate, if applicable)
n=74						
Vermöhlen 2017[114] n=40	Yes	Yes	NA	Yes	Yes	RCT; adequate sequence generation and allocation concealment; blinded outcome assessment
Wickham 2000[115] n=24	No	No	NA	Yes	No	Non-random (control group selected to match intervention group) pre-post; limited demographic information
Wu 2000[116] n=143	No	Yes	NA	Yes	No	Subset from larger project; study-created questionnaire piloted and revised before administration; self-report
Yazicioglu 2012[117] n=60	Yes	Yes	NA	Yes	Yes	Self-report
You 2016 n=35[118]	Yes	Yes	NA	Yes	Yes	Survey (unclear how administered) and clinical assessment; incidence and correlation data
Zoerink 2015[119] n=11	No	No	NA	Yes	Yes	Pre-post design; each participants data collected at both time points by same research assistant
Zwierzchowska 2017[120] n=36	Yes	Yes	NA	Yes	Yes	Self-report

ICF=International Classification of Functioning, Disability, and Health; NA=not applicable; RCT=randomized controlled trial

APPENDIX F. MOTIVATORS OF PARTICIPATION

Figure 1. Motivators to Adaptive Sports Participation