Australian Physical Activity Clinical Practice Guideline

for people with moderate to severe traumatic brain injury

2024

Technical Report

The BRIDGES Guideline Development Group

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Introduction

In 2020 the World Health Organization (WHO) released the first international physical activity and sedentary behaviour public health guideline for people living with disability (Carty et al., 2021). However, the evidence informing the guideline was not specific to people with traumatic brain injury (TBI), nor did it provide guidance for health professionals on the prescription and promotion of physical activity in rehabilitation settings. We developed the first *Australian Physical Activity Clinical Practice Guideline for people living with moderate to severe TBI* (msTBI) to support health professionals' clinical decision-making and increase uptake of physical activity by people of all ages living with msTBI.

The guideline was developed using a Grading of Recommendations Assessment, Development and Evaluation (GRADE) ADOLOPMENT approach to determine whether to 'adapt' or 'adopt' the WHO guideline or develop *de novo* recommendations (Schünemann et al., 2017). This technical report outlines the methods applied to systematically review the evidence for key clinical questions for the guideline.

The evidence review process was conducted by the Guideline Steering Group and overseen by the Guideline Leadership Group. The process for developing the guideline involved:

1. Development of priority key clinical questions.
2. A rapid systemic review to identify direct evidence in msTBI, and where no evidence was identified, review of existing relevant high-quality guidelines and systematic reviews in other relevant health conditions (i.e., stroke, cerebral palsy) and WHO physical activity and sedentary behaviour guidelines for people living with disability.
3. An audit of brain injury services in Australia and qualitative consultations with key stakeholders, including people with msTBI, to inform implementation considerations.
4. Formulation of evidence-based recommendations, good practice, and precautionary points by members of the Guideline Development Group.
5. Release of the draft guideline for public consultation and subsequent revision, including review and endorsement by relevant professional organisations.
6. Independent AGREE II review of the guideline.
7. Independent expert peer-review, including NHMRC-commissioned methodological review.

Key clinical questions

We used a PICO (i.e., Population, Intervention, Comparison, Outcome) framework to develop the key clinical questions of interest for the Australian Physical Activity Clinical Practice Guideline.

1. Should structured aerobic exercise training compared to control be used for adults and older adults with moderate to severe traumatic brain injury?
2. Should structured aerobic exercise training compared to control be used for children and adolescents with moderate to severe traumatic brain injury?
3. Should structured muscle strengthening training compared to control be used for adults and older adults with moderate to severe traumatic brain injury?

4. Should structured muscle strengthening training compared to control be used for children and adolescents with moderate to severe traumatic brain injury?
5. Should structured mobility training (i.e., gait, balance, and function training) compared to control be used for adults and older adults with moderate to severe traumatic brain injury?
6. Should structured mobility training (i.e., gait, balance, and function training) compared to control be used for children and adolescents with moderate to severe traumatic brain injury?
7. Should sport and physical recreation compared to control be used for adults and older adults with moderate to severe traumatic brain injury?
8. Should sport and physical recreation compared to control be used for children and adolescents with moderate to severe traumatic brain injury?
9. Should overall physical activity promotion compared to control be used for adults and older adults with moderate to severe traumatic brain injury?
10. Should overall physical activity promotion compared to control be used for children and adolescents with moderate to severe traumatic brain injury?

Methods

Selection of questions and outcomes of interest

The clinical questions addressed in this guideline are presented in the PICO format (i.e., Participant, Intervention, Comparison, and Outcome). The clinical questions were drafted by the Guideline Steering Group prior to commencing the guideline reviews and presented to the Guideline Leadership Group for discussion and approval of their adoption. Two PICO's were removed during the guideline review process, as the research evidence informing multicomponent intervention recommendations were better suited incorporated into the other clinical questions.

A range of outcomes were identified and selected for ranking of importance based on the patient perspective. The outcomes for consideration were 1) based on those evaluated in the development of the WHO physical activity and sedentary behaviour guidelines for people living with disability (Carty et al., 2021), 2) focused on body function and structure, activity and participation domains of the International Classification of Functioning, Disability and Health framework (WHO, 2001), and 3) additional outcomes considered by the Guideline Leadership Group (including a member with lived experience) of importance for people living with msTBI. From a list of 15 outcomes, the Guideline Leadership Group ranked each outcome in terms of level of importance to a person with msTBI for each clinical question. Only outcomes ranked critical (score 7-9/9) or important (score 4-6/9) for decision-making were included in the final list of outcomes, and the total number of outcomes for each clinical question was limited to the seven highest ranked outcomes.

GRADE ADOLOPMENT process

A GRADE ADOLOPMENT methodology (Schünemann et al., 2017) was used to develop the *Australian Physical Activity Clinical Practice Guideline for people living with moderate to severe TBI*. Based on the GRADE ADOLOPMENT framework as outlined by Schünemann et al. (2017) and as described by Okely et al. (2022) in the development of the Australian 24-hr movement guidelines for children and adolescents, the following steps were taken:

1. Establishment of a Guideline Leadership Group.
2. Formation of a Guideline Development Group.
3. Identification of credible existing guidelines and definition of criteria for selection of the guidelines.
4. Evaluate and complete GRADE Evidence to Decision (EtD) frameworks for each recommendation of the selected guidelines.
5. Determine availability, completeness, and currency of information about EtD criteria.
6. Stakeholder consultations.
7. Dissemination, surveillance, and evaluation.

Establishment of Guideline Groups

Three groups were responsible for the development of the *Australian Physical Activity Clinical Practice Guideline for people living with moderate to severe TBI*. Members of the groups were identified by A/Prof Hassett and Dr Johnson, and either approached directly by A/Prof Hassett or appointed by their organisation. All members of the Guideline Leadership Group were involved in developing the scope and processes for each group. Only members of the Guideline Development Group were involved in deciding on the recommendations, including their wording, contained within the clinical guidelines. The three groups were the:

Guideline Steering Group

- Led by the guideline chair, and BRIDGES chief investigator, Associate Professor Leanne Hassett (LH) and guideline co-chair, and BRIDGES postdoctoral research fellow, Dr Liam Johnson, (LJ). This group consisted of a qualitative researcher (AH), three research officers (SC, KW, DC), one research assistant (BW) and one postgraduate student (PA) that met weekly to manage the development of the guideline. A second postgraduate student (EB) was added to the Steering Group in the later stages of the project to assist with data extraction and completing the GRADE EtD frameworks. The group were tasked with searching the evidence, data extraction, collating and appraising the evidence, conducting the quantitative and qualitative additional BRIDGES studies, completing the EtD frameworks and drafting the initial guideline recommendations. This group reported back to the Guideline Leadership Group.

Guideline Leadership Group

- Led by the guideline chair (LH) and co-chair (LJ), this group consisted of the BRIDGES project chief investigators (GW, CS, AT, AB, AS, ST, KC, LW, and GV), methodologist (ZM), and an academic/researcher experienced in physical activity guideline development and the GRADE ADOLOPMENT methodology (AO). As the guideline sought to initially 'adapt' or 'adopt' the WHO physical activity and sedentary behaviour guideline for people living with disability using the GRADE-ADOLOPMENT process (assuming the WHO Guideline would be appropriate as per Step 3 – identification of credible existing guidelines [see below for details]), the lead author on the WHO physical activity and sedentary behaviour guideline for people living with disability (CC) was invited on to the Guideline Leadership Group. The Guideline Leadership Group met monthly from October 2022 to June 2023 to receive progress reports from the Guideline Steering Group. The Guideline Leadership Group were tasked with oversight of the development of the guideline, including ranking the outcomes of interest by importance, selecting credible guidelines for GRADE ADOLOPMENT, identification of the Guideline Development Group members and peer reviewers of the guideline, approving the initial recommendations and participation in the Guideline Development meetings. The Guideline Leadership Group also underwent training by an expert in GRADE methodology (Prof. Zachary Munn) in the application of the EtD framework.

Guideline Development Group

- In addition to the Guideline Steering and Leadership Group members, other key stakeholders representing all states and territories of Australia, including people with lived experience, family and caregivers, clinicians and researchers working with children, adolescents and adults living with msTBI, methodological experts, community-based physical activity providers, patient advocacy groups, and funding agencies. The Guideline Development Group met on five occasions (13.5 hours) over a 3-week period via Zoom to discuss the recommendations and vote on the type and wording for each recommendation. Guidance on the application of the GRADE methodology and understanding of the EtD framework was provided during the first Guideline Development Group meeting by methodologist Prof. Zachary Munn.

Identification of credible existing guidelines

We identified and prioritised potentially relevant and credible existing guidelines from which to 'adapt' or 'adopt' to develop our guideline, and then applied the following GRADE ADOLOPMENT (Schünemann et al., 2017) criteria to determine their selection for our guideline:

1. Published in the past ten years (or in the process of being published).
2. Addressed clear research questions (contained all PICO elements).
3. Followed the GRADE process.
4. Allowed for updating (provided access to full systematic reviews, which were registered with the Prospective Register of Systematic Reviews [PROSPERO] and provided full access to the search strategy).
5. Included existing and accessible GRADE and summaries of findings tables.
6. Completed a risk-of bias assessment.

We also rated the identified guidelines on whether they included costs associated with implementing the guideline, information on guideline implementation and dissemination, and whether they included benefits and harms assessments for patient-important outcomes. A total of 13 guidelines were rated. (Appendix 1 contains a summary of the guidelines that the Guideline Steering Group identified and evaluated against the criteria). The Guideline Steering Group then submitted their recommendations to the Guideline Leadership Group for use of the WHO physical activity and sedentary behaviour guideline for people living with disability (Carty et al., 2021) (or other identified guidelines) for approval to be adopted/adapted/used for *de novo* recommendations based on the following criteria:

1. Quality of guideline (assessed using the GIN-McMaster Guideline Development Checklist [Schünemann et al., 2014]).
2. Appropriate scope/applicability for Australia. For example, the target population and interventions in the guideline are appropriate (i.e., evidence synthesis or guideline for adaptation/adoption addressed question(s) in similar population).
3. Topic is a priority for Australia (i.e., high burden, inappropriate practice patterns, ongoing controversy, perceived biggest health impact and best evidence, with emphasis on areas with existing quality gaps, consider resources and cost savings, no recent well-developed guidelines about proposed topic).
4. Research questions and PICOs for the systematic reviews that served as the evidence base for the guideline are relevant to our topic and clinical questions.

Evaluate and complete GRADE Evidence to Decision (EtD) frameworks for each clinical question

Following discussions by the Guideline Leadership Group, it was agreed that the WHO physical activity and sedentary behaviour guideline for people living with disability (Carty et al., 2021), Australian 'living' stroke guideline (https://informme.org.au/guidelines/living-clinical-guidelines-for-strokemanagement, 2022), and cerebral palsy guideline (Jackman et al., 2022) were identified as being credible existing guidelines. However, all three guidelines demonstrated questionable relevance and applicability, particularly with respect to their limited applicability to the condition (i.e., people with msTBI) and setting (i.e., rehabilitation and transitional care were not considered in the WHO guidelines). The Guideline Leadership Group then decided the creation of *de novo* recommendations was more appropriate than the adaptation or adoption of existing guidelines. It was agreed that the three identified guidelines could provide credible indirect evidence where there was no/limited evidence in msTBI.

Determine availability, completeness, and currency of information about EtD criteria

Given the lack of direct evidence that could be acquired from the WHO physical activity guideline, or other guidelines, the Guideline Leadership Group decided on an update to a recent rapid systematic review (Johnson et al., 2023) as the best source of direct evidence to inform the development of *de novo* recommendations.

It was also decided by the Guideline Leadership Group to update the search strategy used by the WHO physical activity and sedentary behaviour guideline for people living with disability (Carty et al., 2021) to examine the association between physical activity and health-related outcomes among people with stroke given the overlap in impairments experienced by stroke survivors and people with msTBI. The updated search strategy was run, and the identified systematic reviews were evaluated for credibility using the AMSTAR 2 (A MeaSurement Tool to Assess systematic Reviews) instrument (Shea et al., 2017). Broadly, the systematic reviews identified from the updated search had many limitations in their design, execution, and reporting. Only one of the systematic reviews was rated as having high credibility based on the AMSTAR 2 instrument (Shea et al., 2017). One was rated as having moderate credibility, two were rated as having low credibility, and the remaining 31 were rated as having critically low credibility. Given concerns regarding the comprehensiveness and the validity of the results presented in reviews rated as having critically low credibility, they were not incorporated into the final evidence profiles. Appendix 2 presents the evidence profile and extracted data for each included review updated from the original WHO physical activity and sedentary behaviour guideline search strategy for people living with disability (Carty et al., 2021), and the ratings for each review considered for inclusion according to the AMSTAR 2 domains.

Systematic Review of the evidence to inform the Guideline

Aim of the systematic review

An update of a rapid systematic review (Johnson et al., 2023) was conducted, with the aim to determine the effectiveness of physical activity interventions compared to either i) usual care, ii) a physical activity intervention with different parameters (i.e., dose, setting, or supervision), iii) a non-physical activity intervention, or iv) no intervention on primary and secondary outcomes (see below) in people with msTBI.

Methods

Types of studies

Due to the lack of evidence found in our initial rapid systematic review (Johnson et al., 2023), we extended the search for this systematic review to include published randomised controlled trials (RCTs, including cross-over RCTs) and non-randomised studies of interventions (NRSIs). Trials with more than two parallel comparisons were included if two of the comparisons met the inclusion criteria. If trials were reported in more than one publication or interim analyses were published prior to the completion of the trial, then the most recent publication was used. Only trials published in English were included.

Types of participants

Children, adolescents, adults, and older adults with msTBI were included. Trials with a mix of participants with different neurological conditions (i.e., stroke, Parkinson's disease) were also included regardless of the percentage of participants within the trial with a diagnosis of msTBI.

Types of interventions

We included studies of any physical activity intervention, therapeutic or non-therapeutic, that would contribute to the person meeting the WHO physical activity guideline. Physical activity was defined here, in accordance with WHO, as 'any activity involving bodily movement produced by skeletal muscles that requires energy expenditure' (WHO, 2020). We included: structured aerobic training, structured muscle strengthening, structured gait/balance/function training, structured multicomponent training, sport and physical recreation, and overall physical activity promotion. The intervention may be delivered as a standalone intervention or as part of a rehabilitation package. The intervention may be implemented as an inpatient, outpatient, or community-based program, may be supervised or self-led, and be in a health, home, work, school, or community setting. Given the inclusion of rehabilitation-based studies, where interventions incorporated robotics that passively assisted movement, we only included studies where the intervention required the person to produce at least 50% voluntary/unassisted activity.

Types of comparisons

RCTs and NRSIs were included if they compared the interventions of interest with i) usual care, ii) a physical activity intervention with different parameters (i.e., dose, setting, or supervision), iii) a non-physical activity intervention, or iv) no intervention. Trials that compared interventions with an alternate intervention were also included if they were a PICO of interest. Trials that included a co-intervention or usual care were included if the co-intervention or usual care were administered to both groups (making it possible to determine the added benefit of the intervention of interest).

Types of outcome measures

Trials were included that contained an outcome relevant to a clinical question. These typically included measures of physical function (i.e., cardiorespiratory fitness, mobility, balance, muscle strength, body composition, walking capacity, and fatigue), cognition, quality of life, comorbidities and mortality, mood, participation, physical activity, social connection, behaviour change, and pain.

Search methods for identification of studies

The following electronic databases were searched to identify reports of relevant studies:

Ovid MEDLINE (1946 to December 24th 2022); Ovid CENTRAL (1991 to December 24th 2022) and EBSCO SPORTDiscus (searched December 24th 2022). To search the databases, we used search terms for RCTs, systematic reviews and meta-analyses, and non-randomised study designs, and combined these with search terms for physical activity and TBI. Full search strategies can be found in Appendix 3.

Searching other resources

We also searched the reference lists of all identified systematic reviews.

Selection of studies

11,400 articles were initially imported into Endnote before duplicates were removed and the remaining records were imported into a web-based data management platform (Covidence 2020 v1517, Melbourne, Australia) for screening. Using the eligibility criteria described above, a team of five reviewers completed the title and abstract screening of 11,382 articles. Two reviewers independently screened all records, with conflict resolution completed by a third reviewer (LJ). The same team of reviewers completed the full text screening of 213 articles. Each full text record was screened by two reviewers independently, with studies excluded based on the predetermined exclusion criteria. Conflict resolution was completed by a third reviewer (LJ). One author then selected studies from the identified list and matched them to each clinical question. In total, 128 articles were included in the review (See Figure 1 for flow of records).

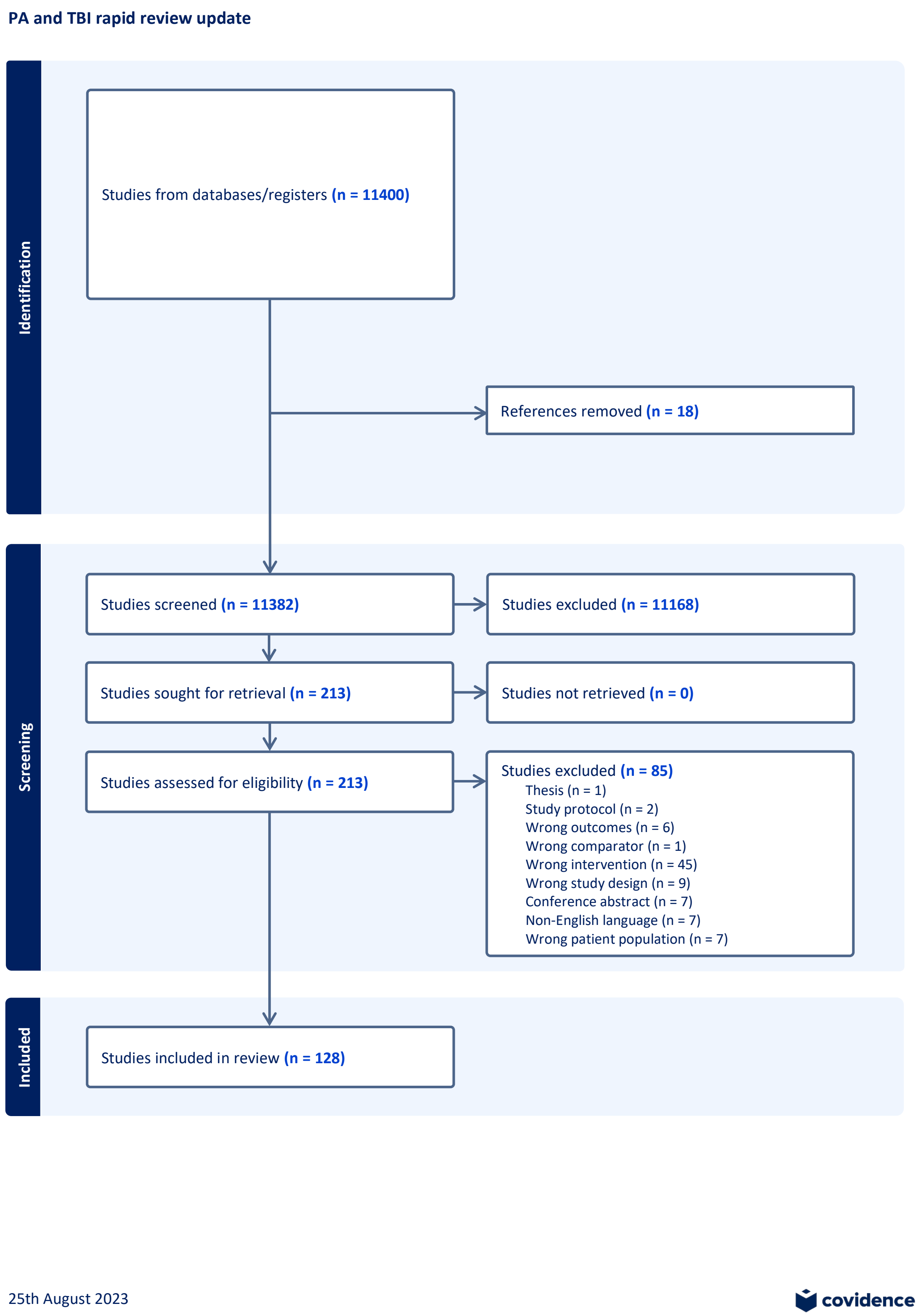

Figure 1: PRISMA diagram

Data extraction and management

Data extraction was completed by a single reviewer from the review team using a self-developed, customised data extraction template in a Microsoft Excel spreadsheet. The data extraction form was developed and piloted on two studies initially by two reviewers (PA and BW). Data extraction included information on:

- Study design, setting, and location
- Sample size and sample characteristics (i.e., age, gender, injury severity)
- Intervention components (i.e., frequency, intensity, time, and type)
- Comparison intervention
- Outcome measures
- Key findings

In studies that included mixed study populations (i.e., mild, moderate, and severe TBI, msTBI and other acquired brain injuries), where possible, only msTBI data were extracted. If this was not possible, group data was used in the synthesis and analysis Where multiple outcome measures were used in a single study to assess the same, or similar, construct, we chose the outcome measure without looking at the results of the trial, prioritised measures that were considered important to health professionals and people with msTBI given our experience in the field and knowledge of the literature.

Details of data extraction for synthesis

A single reviewer extracted data from each study to determine mean between-group differences and 95% confidence intervals (95% CI). This included outcome scores and number of participants overall, and in each group. Data were estimated from graphs if necessary, using WebPlotDigitizer (Rohatgi, 2021). The following rules were used (from first to last) when deciding upon which data to extract:

- Mean between-group difference in post-intervention scores.
- Mean and standard deviation (SD) of change scores provided in the studies (post-intervention scores and change scores were not pooled in meta-analyses in which results were expressed as standardised mean differences (SMD)).
- Mean (SD) post-intervention scores.

Where median and interquartile range (IQR) were reported, the mean and SD were calculated as per the quantile estimation method described by McGrath et al. (2020). First period data only was extracted if possible from cross-over studies. Review Manager software (RevMan 5.4.1) was used to convert 95% CIs, standard errors, p-values and any other appropriate combination of data or statistical results into SDs when necessary. The direction of effect of each outcome was standardised.

Assessment of risk of bias in included studies

We assessed the risk of bias in each trial using Cochrane risk-of bias (RoB) tools. For RCTs and cross-over RCTs, the RoB-2 (Sterne et al., 2019) was used, while for NRSI, the ROBINS-I (Sterne et al., 2016) instrument was used. For RCTs, cross-over RCTs, and NRSIs, a single reviewer independently assessed the domains of potential bias arising for each domain of the relevant tool. The level of potential bias was judged as low, high or unclear (due to a lack of information or uncertainty) for each domain.

Measures of treatment effect

Meta-analyses were conducted across studies that made similar comparisons if there were at least two studies without excessive clinical heterogeneity. Clinical heterogeneity was assessed by examining the type of participants, type and intensity of the intervention, and other issues related to the design and conduct of the studies. If studies in a meta-analysis used the same measure and same units, effects were expressed as mean differences (MD) and 95% CI using a random-effects model. Where outcomes were measured using different assessments/measures, we calculated the SMD (Hedges' g) and 95% CI using a random-effects model to pool estimates. Where change scores were reported, these were pooled with end of intervention and/or end of follow-up scores for analysis but are presented for these studies as separate subgroups (Deeks et al., 2022). Effect sizes were categorised as small (0.1 to 0.4), medium (0.5 to 0.7) or large (0.8 or greater). Where it was not possible or appropriate to pool data, study results were narratively synthesised. Data were analysed using RevMan v5.4.1. A lack of overall data meant no sub-group or sensitivity analysis were performed.

Unit of analysis issues

Unit of analysis issues were considered in the following two cases:

1. Cross-over trials: In cross-over trials data were analysed from the first period if available.
2. Trials where multiple measures were taken on the same participant: In trials where multiple measures were taken on the same participant data at the end of the intervention period and at follow-up were used and analysed and reported separately.

Dealing with missing data

All feasible available results were included. Only published data was extracted to use in analysis. All available data were converted where possible (for example, when data were reported as standard errors) using the calculator incorporated into RevMan.

Assessment of heterogeneity

Heterogeneity was determined by visual inspection of the forest plots and with consideration of the I2 test. We did not test for publication bias due to the small number of studies included in the meta-analysis.

Use of further evidence

Additional studies were completed to complement the evidence review but are not components of the GRADE ADOLOPMENT process. Their inclusion as part of the development of the guideline was considered important when determining the acceptability, feasibility, and resource requirements of the guideline for the Australian context and with key stakeholders, as well as to inform development of plans for future implementation of the guideline, including monitoring and surveillance.

Brain Injury rehabilitation services audit

Background and aims:
The aim of the *Australian Physical Activity Clinical Practice Guideline for people living with moderate to severe TBI* is to facilitate consistent implementation of evidence-based care across Australia to improve the overall quality of life of people with msTBI. An important aspect of the guideline development is to understand the feasibility of the guideline to be implemented into the Australian healthcare system for Australians living with msTBI. At present, we do not know how physical activity is being delivered and/or promoted in rehabilitation to people with msTBI. The aim of this study was to conduct an audit of specialist and non-specialist brain injury services across Australia by surveying health professionals (predominantly physiotherapists and exercise physiologists) within these services to identify:

1. How physical activity is promoted, prescribed, and provided for people with msTBI (including resources such as equipment used).
2. Factors that influence the ability of health professionals to promote, prescribe, and provide physical activity to people with msTBI.
3. Policies, procedures, and resources including equipment for providing physical activity to people with msTBI.

Methods:
We conducted an online audit via a REDCap survey of specialist and non-specialist brain injury services across Australia. Inclusion criteria of services included: 1) specialist brain injury rehabilitation services; 2) non-specialist rehabilitation inpatient services who have a minimum of at least three patients with TBI in their service per year (across 2019 and 2020) as identified through the Australian Rehabilitation Outcome Centre (AROC); and 3) multidisciplinary private practice outpatient and domiciliary services that specialise in working with people with brain injury (at least three patients with msTBI in their service per year) identified through project investigator networks. Recruitment of specialist brain injury services and non-specialist inpatient rehabilitation services was conducted through AROC who identified eligible services from their national rehabilitation data across 2019 and 2020. Services that met the audit inclusion criteria were invited by AROC via email, with a follow-up email provided if necessary. Multidisciplinary private practice services were invited by email via a BRIDGES team email. Project investigators also distributed an email through their TBI networks to maximise recruitment.

Sample size:
In collaboration with AROC, we identified 20 specialist brain injury services with inpatient teams, and 14 general rehabilitation inpatient teams with at least three TBI occasions of

service per year (in both 2019 and 2020). BRIDGES investigator networks identified an additional 58 outpatient, transitional and domiciliary services. Within each identified service, we invited a physiotherapist or exercise physiologist to complete the audit survey on behalf of, and in collaboration with, their service. The nominated site champion (i.e., a physiotherapist or exercise physiologist) within these services was asked to answer questions about the following domains: 1) general information about the service; and 2) specific information about physical activity provision and promotion, including barriers related to the provision and prescription of physical activity (i.e., aerobic exercise, strength training, mobility training, multi-component group exercise, sport and physical recreation) and overall promotion of physical activity. The nominated site champions were also asked to upload and share any local resources supporting physical activity provision and/or promotion (e.g., fitness testing policies and procedures). See Appendix 4 for a copy of the audit survey.

To complement the audit and as a way of verifying data collected, single-day observations were also undertaken at two adult and one paediatric brain injury services. Health professionals were observed treating patients with msTBI (who were aware of the observation) in the physiotherapy gym and a checklist developed from the audit was used to document how physical activity was prescribed and promoted, including equipment used.

Ethics:
This study was approved by The University of Sydney Human Research Ethics Committee (2022/773). The site audit was also approved through South Western Sydney Local Health District Human Research Ethics Committee (2022/ETH02065) and local health services governance approvals were received for the observations.

Qualitative interview and focus groups with people with lived experience

Background and aims:
An important aspect of the guideline development is to understand preferences for physical activity for people with msTBI. For example, do they have preferences of the types of physical activity available, where it is provided and who it is provided by? Understanding these issues will enable us to develop a relevant guideline and promote and lobby for preferred physical activity opportunities to be available for people with msTBI. The aims of this study are to use qualitative research methods to:

1. Inform the identification and description of physical activity attributes and levels from people with msTBI for use in a Discrete Choice Experiment (DCE) in this population.
2. Explore the relationships and interdependencies between different factors identified as being influential to people with msTBI preferences for physical activity.
3. Identify meaningful appropriate language for people with msTBI, including obtaining feedback on the understandability of pilot DCE instructions and layout.

Methods:
We conducted a study using qualitative approaches to generate attributes for a DCE on physical activity. Data was collected using focus groups and interviews and analysed using a qualitative descriptive approach to identify key concepts of physical activity participation by our four stakeholder groups: children (10+ years), adolescents, adults, and older adults living with msTBI. The study was guided by the reporting guideline for recommended reporting of qualitative studies to inform quantitative preference studies (Hollin et al., 2020). The detailed methods of this study have been published (Haynes et al., 2023). The final DCE survey is currently open and being completed by people with msTBI across Australia. The qualitative work to develop the DCE has been used to inform the development of this guideline. The final DCE survey results will aid with implementation of the guideline and advocacy for appropriate physical activity opportunities.

Ethics:
This study was approved by The University of Sydney Human Research Ethics Committee (2022/088). The final DCE Survey was also approved by South Western Sydney Local Health District Human Research Ethics Committee (2022/ETH02065) and local health services governance approvals were received where necessary.

Stakeholder focus group interviews

Background and aims:
An important aspect of the guideline development is to understand perceived barriers and facilitators of physical activity participation for people with msTBI. We need to understand the different views and perspectives of those who participate in the activities (i.e., people with msTBI), and the primary groups of people who influence physical activity participation and promotion, such as those who fund, supervise, or deliver physical activity. Understanding the various views and perspectives will enable us to develop a relevant guideline and promote and lobby for physical activity opportunities to be available for people with msTBI.

The aim of this study was to conduct focus groups with key stakeholders (people with msTBI, family members, support workers, community-based physical activity providers, health professionals, and service funders) to identify barriers and facilitators to physical activity participation for people with msTBI, and how the guideline can be tailored to their needs.

Methods:
We conducted a qualitative cross-sectional study to explore potential barriers and facilitators of physical activity participation for people with msTBI. Data was collected using online focus groups and individual interviews via zoom. Data was analysed using a qualitative descriptive approach (Sandelowski et al., 2000) to identify key concepts of physical activity participation by our six stakeholder groups: 1) adults with msTBI, 2) family members, 3) support workers/attendant carers, 4) health professionals, 5) community-based physical activity providers, and 6) service funders. Identified barriers and facilitators were categorised using

the socioecological model (Bronfenbrenner, 1994) to identify influences on physical activity at the individual, interpersonal, community, and policy levels.

Recruitment:
We approached key organisations in TBI to circulate recruitment flyers through their organisations' usual communications with members (e.g., emails, newsletters, social media posts, and announcements). We used a passive snowballing approach to recruit participants for under-represented stakeholder groups. For example, health professionals may let their colleagues, or people living with msTBI, or their family, know about the study, or vice versa (e.g., a person living with msTBI may let their relative or support people know about the study). Additionally, BRIDGES investigators and study collaborators used passive snowballing to let their colleagues or people in their professional networks (where there are no power imbalances) know about the study. Social media posts were also used by the research team.

Sample size:
As is common in qualitative research, our sample size was not fixed. However, we aimed to recruit a total of around 28 to 43 participants so that all stakeholder groups were well represented in the study.

Procedure:
The focus groups were facilitated by two members of the Guideline Steering Group (led by KW and supported by LH), with guidance from our qualitative expert (AH). A focus group discussion guide was used flexibly to encourage participants (within the same stakeholder group) to share their experiences and opinions of the suitability of the WHO physical activity and sedentary behaviour guideline, and barriers and facilitators of physical activity participation for Australians living with msTBI. For participants with msTBI, strategies were incorporated in the focus group to be inclusive of people with a range of disabilities (Trevisan et al., 2021). Audio-recordings of the focus groups and interviews were professionally transcribed. The data were analysed using a qualitative description approach.

Ethics:
This study was approved by The University of Sydney Human Research Ethics Committee (2022/435).

Evidence review and development of clinical recommendations

The GRADE approach was used for the development of recommendations (Schünemann et al., 2013). The Guideline Development Group used the GRADE EtD framework to make recommendations for each clinical question. The EtD framework is a well-established, systematic, structured and transparent approach to decision-making, encapsulating research evidence, the certainty of the evidence, and where required expert opinion and topical knowledge from key stakeholders. The EtD framework uses explicit criteria to generate guideline recommendations, including whether the problem is a priority, the balance between the observed evidence of desirable and undesirable outcomes, overall certainty of evidence, relative values of patients for desirable and undesirable outcomes, resource use (cost considerations) where applicable, impact of recommendation on health inequities, and the acceptability and feasibility of recommendations. A standardised process that included voting on the EtD criteria judgements was undertaken to inform the decision-making on strong or conditional evidence recommendations for or against an intervention.

GRADEpro GDT (GRADEpro Guideline Development Tool [Software]. McMaster University and Evidence Prime, 2023. Available from gradepro.org) was used by three members of the Guideline Steering Group (LH, LJ, BW) to create the draft EtD frameworks and recommendations to be taken to the Guideline Development Group to decide on. GRADEpro GDT is an easy to use, all-in-one web solution to summarise and present information for guideline development.

Assessing certainty of the evidence

The evidence from the systematic review was independently graded for certainty, using the GRADE approach, by a single reviewer. The GRADE approach defines the certainty of the evidence as *very low, low, moderate,* or *high certainty* (Table 1). The following criteria are considered: study design, RoB, consistency of effect, indirectness, precision of effect, and other limitations, including publication bias and other factors for upgrading (magnitude of effect, dose-response, and effects of confounders).

Table 1. GRADE levels of evidence quality

Certainty	Definition
High	We are very confident that the true effect lies close to that of the estimate of the effect
Moderate	We are moderately confident in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect
Very low	We have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of effect.

Development of evidence recommendations

The evidence recommendations were made by initially considering the size and precision of treatment effects along with the quality of the evidence. Our decision as to when to use direct TBI evidence from non-randomized studies of interventions (NRSIs) was guided by the process recommended by Cuello-Garcia et al. (2022). Where limited direct evidence was available, data and/or rating of certainty of evidence from the WHO physical activity and sedentary behaviour guideline, stroke (adults), or cerebral palsy (children) guidelines was added to the EtD frameworks to determine effect and certainty of effect. We then considered the balance between benefits and harms, values and preferences, resource use and other relevant considerations including equity, accessibility, and feasibility. These considerations were documented by three authors in an EtD table for each clinical question

(Schünemann et al., 2013). Data from BRIDGES studies (audit and qualitative studies) provided information on values, resources, acceptability, and feasibility of the intervention. Figure 2 overviews the different evidence sources contributing to the guideline recommendations. The direction of each recommendation was expressed using the language described by GRADE as a recommendation FOR an intervention, AGAINST an intervention or NO recommendation (Table 2). The strength of a recommendation for or against an intervention was expressed as **strong** or **conditional**. Each recommendation required greater than 50% agreement by the Guideline Development Group within three rounds of voting. Definitions from the GRADE Handbook were used throughout the guideline development process (Schünemann et al., 2013).

GRADE defines a STRONG recommendation as:
"A strong recommendation is one for which guideline panel is confident that the desirable effects of an intervention outweigh its undesirable effects (for an intervention) or that the undesirable effects of an intervention outweigh its desirable effects (against an intervention)."

GRADE defines a CONDITIONAL recommendation as:
"A conditional recommendation is one for which the desirable effects probably outweigh the undesirable effects (for an intervention) or undesirable effects probably outweigh the desirable effects (against an intervention) but appreciable uncertainty exists."

GRADE defines NO recommendation as justified when:
"The panel feels a recommendation is too speculative or the panel has difficulty deciding on the direction of the recommendation." (Schünemann et al., 2013).

Table 2. Summary of the strength of the evidence recommendations. The hierarchy is based on the GRADE approach (Schünemann et al., 2013).

Evidence Recommendation	Explanation
Strong evidence recommendation **FOR**	The guideline panel is confident that they can recommend the intervention based on the evidence. A recommendation is made that the intervention should be implemented
Conditional* evidence recommendation **FOR**	The guideline panel is confident that they can probably recommend the intervention based on the evidence. A recommendation is made that the intervention may be implemented
Conditional* evidence recommendation **AGAINST**	The guideline panel is confident that they probably cannot recommend the intervention based on the evidence. A recommendation is made that the intervention should not be implemented
Strong evidence recommendation **AGAINST**	The guideline panel is confident that they cannot recommend the intervention based on the evidence.

	A recommendation is made that the intervention should definitely not be implemented
No recommendation	The guideline panel is unable to recommend for or against the intervention based on the evidence. A consensus-based opinion statement will be made.

* This table has been adapted from Schünemann et al. (2013) by replacing the term '*weak*' with '*conditional*' to avoid the potential unintended negative connotations and confusion associated with the term '*weak*'.

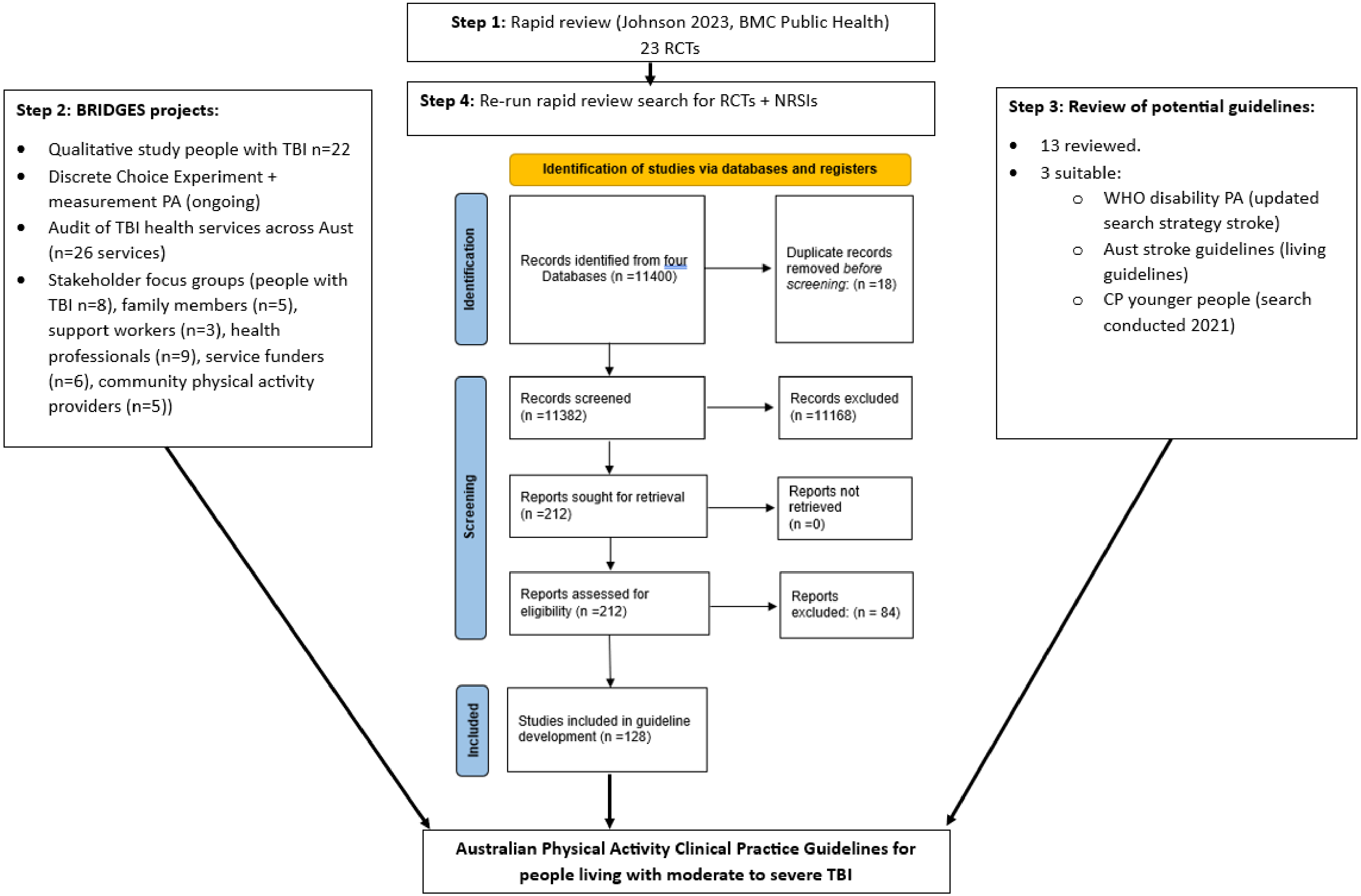

Figure 2: Evidence and Studies Informing Guideline

Development of Good Practice Points and Precautionary Points
Good practice points were written to accompany the evidence recommendations where required. The good practice points were based on the expert opinion of the Guideline Development Group and from evidence provided from included studies and are intended to further guide clinical decision-making alongside the clinical recommendations. Where appropriate, precautionary points were also included, which again were based on the expert opinion of the Guideline Development Group and data from relevant research.

Guideline Development Group meetings
The Guideline Development Group meetings were conducted online (via Zoom) over two*four-hour meetings, two*two hour meetings and one*one and a half hour meeting spread across five days over a three-week period (13.5 hours in total). The meeting attendees and voting records for the EtD criteria judgements (where necessary), direction and strength of recommendations, and the wording of recommendations, can be found in Appendix 5.

Following consultation with the Guideline Leadership Group to discuss and plan the Guideline Development Group meetings, guideline chair and co-chair, A/Prof Leanne Hassett and Dr Liam Johnson respectively, initiated and completed the following processes to ensure a transparent, inclusive and robust process was taken to develop the physical activity clinical practice guideline for people with msTBI.

1. The guidelines chair approached and appointed a meeting chairperson, A/Prof Joanne Glinsky, to run the Guideline Development Group meetings. The role of the chairperson is described in the Administrative Report.
2. The Guideline Steering Group met with Mr Nick Rushworth, Executive Officer of Brain Injury Australia, the nation's peak body representing Australians living with a brain injury, and a person with lived experience of msTBI, for guidance on how to be inclusive and respectful of people with lived experience to ensure they felt heard and valued in the Guideline Development Group meetings.
3. The EtD framework, summary of findings (SoF) tables and evidence profiles for each clinical question were distributed to each member of the Guideline Development Group two weeks prior to the scheduled meetings. Along with the documentation, the guideline chair recorded a brief video presenting key terms and concepts, the process taken to develop the evidence, and make the criteria judgements, and how the draft recommendations were developed, for a single clinical question.
4. Upon Mr Rushworth’s suggestion, the guideline chair and co-chair offered to meet with the people with lived experience on the Guideline Development Group one week prior to the scheduled meetings to discuss (via Zoom) the process taken to develop the draft guidelines, what to expect in the upcoming Guideline Development Group meetings, and to answer any questions the group members had regarding the guideline development process. Two members of the Guideline Development Group with lived experience of msTBI attended this meeting.

5. Following introductions and disclosures of conflicts of interests, a standard process was followed in each Guideline Development Group meeting for each clinical question:
    a. The chairperson announced which clinical question was being discussed and asked if any group members had a conflict to declare. If a group member declared a conflict, it was discussed, and it was determined by the group if the person should abstain from voting on the recommendation. If it was agreed the person would abstain from voting, the person was still invited to contribute to the discussion of the clinical question.
    b. The chairperson invited either the guideline chair or co-chair, to present the EtD framework, including the evidence informing each criteria judgement (i.e., whether the problem is a priority, the balance between the observed evidence of desirable and undesirable outcomes, overall certainty of evidence, relative values of patients for desirable and undesirable outcomes, resource use (cost considerations) where applicable, impact of recommendation on health inequities, and the acceptability and feasibility of recommendations), the SoF tables, RoB assessments, and evidence profiles for a single clinical question.
    c. Each EtD criteria judgement was discussed amongst the Guideline Development Group members.
    d. Where the chairperson felt it was necessary to vote on a particular EtD criteria judgment, which was based on the open discussion by the Guideline Development Group members, a zoom poll was launched and all attendee's (notwithstanding those with a CoI who did not vote), voted on whether to accept or change the rating.
    e. This process continued for each EtD criteria judgement.
    f. The guideline chair or co-chair then presented the direction and strength of the recommendation, which was voted on by the Guideline Development Group members, with 50% agreement required for a recommendation to be accepted.
    g. The guideline chair or co-chair then presented the draft wording of the recommendation, which was then discussed and modified during the meeting. The wording of the recommendation was then voted on, again with 50% agreement required for the wording of the recommendation to be accepted.
    h. Good practice points and precautionary points were then discussed by the Guideline group and the final wording of these points completed by the chair or co-chair after the meeting.

This process was followed for each clinical question in succession.

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Clinical question 1: Aerobic exercise training for adults and older adults with moderate to severe traumatic brain injury

Clinical question

Should structured **aerobic exercise** training compared to control be used for **adults and older adults** with moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home

Perspective: Health systems

Outcomes of interest:

1.	Cardiorespiratory fitness	CRITICAL
2.	Co-morbidities and mortality	CRITICAL
3	Walking capacity	IMPORTANT
4.	Combined mobility	IMPORTANT
5.	Physical activity	IMPORTANT
6.	Body composition	IMPORTANT
7.	Mood	IMPORTANT

Conditional recommendation:

For adults and older adults after moderate to severe traumatic brain injury, we suggest regular structured aerobic exercise that is individually-tailored and across the continuum of care.

Good Practice Points:

We suggest:

- Aerobic exercise aims to achieve participation-level goals established collaboratively.
- Assessment of fitness is conducted prior to commencing an aerobic exercise program using a standardised or modified protocol and pre-exercise screening.
- Aerobic exercise is prescribed using the Frequency, Intensity, Time, and Type (FITT) principles according to American College of Sports Medicine guidelines for stroke and brain injury.
- That specificity of training is considered when prescribing mode of aerobic exercise.

- Exercise dosage is monitored (preferably using a heart rate monitor) when possible.
- Timing of aerobic exercise training considers the impact of fatigue on behaviour and participation in other activities including work and/or study.
- Aerobic exercise is transitioned from health settings to community-based physical activity settings where appropriate.

Precautionary Points:

- For adults on anti-epileptic medication, moderate to high intensity aerobic exercise may increase the risk of seizure if they are medically unwell or are not routinely taking their medication.
- When calculating training heart rate for adults on beta-blocker medication, predicted maximum heart rate should be adjusted to account for the medications' heart rate lowering effect (HRmax pred-adj = 85%(220-age).
- In the acute stage of recovery, consider mode of exercise and seek medical advice prior to commencing aerobic exercise for adults with additional complications such as orthopaedic injuries or craniotomy.

Justification

Overall justification

Cardiorespiratory deconditioning is a common problem after TBI likely to restrict reintegration back into previous roles within family, work and community. Aerobic training is likely to address this problem.

Detailed justification

Problem

Cardiorespiratory deconditioning is a common secondary physical impairment after TBI which can increase risk of morbidity and mortality and reduce participation in everyday activities.

Desirable Effects

Although low or very low certainty evidence of effectiveness, aerobic fitness training may have moderate to large effects on critical and important outcomes for individuals with TBI including cardiorespiratory fitness and mood. Similar and stronger effects have been shown in individuals after stroke.

Balance of effects

There are likely desirable effects and the undesirable effects such as adverse events are likely small (e.g., muscle soreness).

Acceptability

Good acceptability from multiple stakeholders.

Feasibility

Feasible to deliver in inpatient and post-rehabilitation settings, although implementation support will be needed, especially for services and clinicians working with individuals with higher support needs.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large	Varies	Don't know	
UNDESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large	Varies	Don't know	
CERTAINTY OF EVIDENCE	Very low	**Low**	Moderate	High	No included studies		
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	**Favors the intervention**	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High	**No included studies**		
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
FEASIBILITY	No	Probably no	**Probably yes**	Yes	Varies	Don't know	

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

<table>
<tr><th colspan="3">Problem
Is the problem a priority?</th></tr>
<tr><th>JUDGEMENT</th><th>RESEARCH EVIDENCE</th><th>ADDITIONAL CONSIDERATIONS</th></tr>
<tr><td>○ No
○ Probably no
○ Probably yes
● Yes
○ Varies
○ Don't know</td><td>TBI evidence about reduced aerobic fitness:

Reduced aerobic fitness is a secondary physical impairment commonly reported to affect people after TBI both in the short- and long-term. Eleven studies have used the gold standard measurement of aerobic fitness (i.e., peak oxygen uptake [VO2peak] using expired gas analysis) among adults with TBI. The 11 studies provided data for 234 adults who were predominantly males (64%) with an average age of 31 years, who had sustained TBIs of varying severity (at least 50% severe), and who were predominantly more than one year post injury. Only one study included participants who were, on average, less than 6 months post injury. The mean (SD) VO2peak of the 11 studies was 27.2 (6.7) mL·kg−1·min−1 (range 16.6 to 37.1mL·kg−1·min−1) (or 7.6 METs); and a mean 87% (range 67 to 95%) of predicted maximum heart rate was achieved. Comparing these values to age-matched data for able-bodied males (American College of Sports Medicine, 2000), all were below the average fitness level (41 mL·kg−1·min−1); and the pooled mean VO2peak of the 11 studies was below the lowest fitness level rating (i.e., below the 10th percentile fitness level; 32.5 mL·kg−1·min−1). Thus, collectively these studies provide evidence that adults with TBI have markedly lower aerobic fitness levels than their age-matched peers (Hassett 2015).

Reduced aerobic fitness can directly restrict reintegration back into previous roles within their family, work, and community. This is the because the individual may no longer have the aerobic capacity to meet the metabolic demands of the activity (Hassett 2015).

TBI evidence about risk of morbidity and mortality:

A recent study from US-based TBI-models system investigated morbidity and mortality after TBI (Izzy, 2022). The study included 4351 patients with msTBI (median [IQR] age, 47 [30-58] years, 45% of participants were women). All comorbidities in the TBI subgroups emerged within a median (IQR) of 3.5 (1.8-6.0) years after injury. Individuals with msTBI, compared with unexposed patients, had higher risk of mortality (432 deaths [9.9%] vs 250 deaths [5.7%]; $P < .001$); postinjury hypertension (Hazard Ratio, 1.3; 95%CI, 1.1-1.7), coronary artery disease (Hazard Ratio, 2.2; 95%CI, 1.6-3.0), and adrenal insufficiency (Hazard Ratio, 6.2; 95%CI, 2.8-13.0) were also associated with higher mortality.

General population evidence about low aerobic fitness and risk of morbidity and mortality:

Data from the general population shows low fitness increases the risk of morbidity and all-cause mortality (Kodama et al., 2009; Lee, Artero, Sui, & Blair, 2010).

Data from the general population shows that increasing fitness by 1 MET (3.5 mL·kg−1·min−1) can reduce the risk of mortality by 15% (Kodama et al., 2009).</td><td>Nil.</td></tr>
<tr><th colspan="3">Desirable Effects</th></tr>
</table>

How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	**Evidence from TBI:** See summary of findings table below. Improvements in cardiorespiratory fitness are likely to have a moderate to large effect (SMD: 0.53 (0.11 to 0.95)- this converts to a peak oxygen uptake value of 3.9 (0.8 to 7.1) ml/kg/min. The mean difference of 3.9 ml/kg/min is above 1 MET (3.5ml/kg/min) which has been shown in the general population to reduce risk of mortality by 15%. Aerobic fitness training can also provide a moderate reduction in depression (SMD: -0.4 (-0.8 to 0.05), particularly > 6 months post-injury after inpatient rehabilitation (SMD: -0.5 (-0.9 to -0.1). This converts to a reduction on the Hospital Anxiety Depression Scale (depression subscale) of 2.2 points (ranging between a reduction of 4.1 points to a reduction of 0.4 points). No studies have evaluated the effect of aerobic training on morbidity and mortality in adults with TBI, and there were mixed and small effects on combined mobility and walking endurance, and trivial or no effect on body composition. Participation in an aerobic training program increased overall physical activity (mins per week and number of days per week active) in one study when measured at end of intervention program. The certainty of the evidence of effect for all outcomes was rated as low or very low. **Indirect evidence:** **Stroke: Australian and New Zealand Living Clinical Guidelines for Stroke Management:** (Saunders et al., 2020, Cochrane review): • Cardiorespiratory fitness: MD (95%CI) VO2peak: 3.4 (2.98 to 3.83) ml/kg/min; moderate certainty evidence. • Walking capacity (6MWT) MD (95%CI): 33.41 (19.04 to 47.78)m; high certainty evidence. • Combined mobility (Berg Balance Scale) MD (95%CI): 1.92 (0.16 to 3.68) points; moderate certainty evidence. • Death: Risk difference 0.00 (-0.01 to 0.01); low certainty evidence. • Mood: MD (95%CI) Beck Depression Index: -1.22 (-5.62 to 3.19), evidence certainty not specified. **Evidence included in health condition evidence summaries from WHO physical activity guidelines for disability** (Carty 2021): In stroke: There is moderate-certainty evidence for improved gait speed and ability, walking speed, distance and endurance, cardiorespiratory fitness, upper-limb function, sensory motor function of the lower limb, balance, mobility, and activities of daily living.	• American College of Sports Medicine (ACSM) guidelines for fitness training for stroke and brain injury: Frequency 3-5x week; Intensity: 40/50-85%HRR or 40-70%VO2peak, or 13/20 rating on Borg scale; Duration: 20-60mins; Intermittent to continuous; Energy expenditure: 300kcal per session or 1000kcal per week (Palmer-McLean 2009). • RCTs included in TBI cardiorespiratory fitness outcome were prescribed within ACSM guidelines. • Meeting ACSM guidelines may be challenging when individuals are very deconditioned (e.g., inpatient rehabilitation). Studies have demonstrated it can take time to progress to meet these guidelines and some may not achieve the intensity criteria (Jackson et al., 2001; Wolman et al., 1994; Hassett et al., 2012). • For adults on beta-blocker medication, predicted maximum heartrate should be adjusted when calculating training heart rate (HRmax pred-adj = 85%(220-age) (Pollock 1991). • The use of a circuit class where patients rotate around a circuit of exercise stations is one strategy to achieve sufficient dosage of fitness training. This was demonstrated in an observational study (with embedded RCT) including 53 individuals with severe TBI undertaking inpatient rehabilitation. The circuit class provided a low intensity (37% HRR), long-duration (52mins) exercise session that met the caloric fitness criteria of 300 kcal per session for 62% (95% CI 49 to 74) of participants (Hassett et al., 2012).

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Evidence from TBI:** See summary of findings table below. No negative effects found on any of the critical or important outcomes. Adverse events (AEs) were not explicitly mentioned in all studies. No SAEs were reported in any study. Five studies reported minor AEs, mostly muscle soreness and fatigue or musculoskeletal pain. **Indirect evidence:** **Stroke:** (Saunders 2020, Cochrane review): Out of the 32 studies of cardiorespiratory fitness training (1631 participants) only one study reported death (n = 2 in each study arm) as a reason for participant losses. There was no statistically significant overall effect (RD 0.00, 95% CI −0.01 to 0.01; I2 =0%. Low certainty evidence). Like TBI data, not all studies explicitly measured adverse events. Of those that did, AEs included cardiovascular events and falls, reported in both intervention and control groups.	**Clinical expertise input:** Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken. Some adults immediately after TBI may require a craniotomy (the surgical removal of part of the bone from the skull to expose the brain) to manage increased intracranial pressure (ICP). In some instances, cranioplasty (surgical repair of a bone defect in the skull resulting from a previous operation or injury) does not occur for many months and the person may be medically stable and actively participating in rehabilitation. Fitness training may be appropriate but should be discussed with rehabilitation or neurosurgical medical specialist. A helmet or skullcap may need to be worn to protect the skull and mode of aerobic exercise may need to be considered to reduce jolting forces. Some adults after TBI may sustain orthopaedic injuries. For example, in the cohort study described by Wong 2019, 325/613 individuals with TBI (53%) had ≥ 1 orthopaedic injury in addition to their TBI. Fitness training may be appropriate but should be discussed with rehabilitation or orthopaedic medical specialist. Mode of aerobic exercise may need to be considered to reduce jolting forces.

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ● Low ○ Moderate ○ High ○ No included studies	**Evidence from TBI:** See summary of findings table below. Improved cardiorespiratory fitness immediately after intervention and reduced depression immediately after intervention (when interventions delivered > 6months post-injury outside of hospital) rated as low certainty evidence. All other outcomes rated as very low certainty evidence. **Indirect evidence:** **Stroke:** (Saunders 2020, Cochrane review): • Cardiorespiratory fitness: MD (95%CI) VO2peak: 3.4 (2.98 to 3.83) ml/kg/min moderate certainty evidence. • Walking capacity (6MWT) MD (95%CI): 33.41 (19.04 to 47.78) m, high certainty evidence.	In stroke studies, high certainty effect of cardiorespiratory fitness training on walking speed and capacity (6MWT), majority of aerobic interventions included walking exercise e.g., treadmill walking (Saunders 2020).

	• Combined mobility (BBS) MD (95%CI): 1.92 (0.16 to 3.68) points, moderate certainty evidence. • Death: Risk difference 0.00 (-0.01 to 0.01), low certainty evidence. • Mood: MD (95%CI) Beck Depression Index: -1.22 (-5.62 to 3.19), evidence certainty not specified. **WHO physical activity guidelines for disability** (Carty 2021): Adults living with disability should do at least 150–300 min of moderate-intensity aerobic physical activity or do at least 75–150 min of vigorous intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity throughout the week for substantial health benefits. *Strong recommendation, moderate-certainty evidence*	

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted in TBI to inform the value people living with TBI place on the main outcomes. **BRIDGES qualitative research with people living with TBI:** Improved aerobic fitness likely improves physical fatigue (Hassett et al., 2015) which is a common long-term symptom reported by people with TBI limiting their participation in everyday activities (Ponsford et al., 2014). As a common symptom of TBI, fatigue was described as a potential barrier to physical activity by nearly all TBI participants in our qualitative study, even though they recognised the paradox of improving their overall fatigue through tiring physical activity: *"I was lying in a hospital bed for six weeks … then there was muscle wastage for the next 18 months as I tried to recover. So, I didn't have any strength to do anything, which meant I was always fatigued. I feel if you can improve people's strength and fitness, then they can cope with everyday tasks better. That gives them more energy. Therefore, they're less fatigued…. people don't seem to understand that to alleviate that fatigue, you have to work hard, which makes you more fatigued, but in the long run, you become less fatigued. That's the perception I'd like to change."* (P3)	Nil.

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

<table>
<tr><td>○ Favors the comparison
○ Probably favours the comparison
○ Does not favour either the intervention or the comparison
○ Probably favours the intervention
● Favors the intervention
○ Varies
○ Don't know</td><td>See summary of findings table below. Small undesirable effects and moderate desirable effects including potentially large and moderate effects on critical and important outcomes.</td><td>Nil.</td></tr>
<tr><td colspan="3">Resources required
How large are the resource requirements (costs)?"</td></tr>
<tr><td>JUDGEMENT</td><td>RESEARCH EVIDENCE</td><td>ADDITIONAL CONSIDERATIONS</td></tr>
<tr><td>○ Large costs
● Moderate costs
○ Negligible costs and savings
○ Moderate savings
○ Large savings
○ Varies
○ Don't know</td><td>• Cost data is not available from any studies in TBI. The cost of the required resources likely varies depending on the needs of the person with TBI, e.g., if they can independently participate in aerobic training, or if they need one-on-one supervision or specific equipment to facilitate aerobic training.
• A more resource intensive intervention (community fitness-centre based program including 3-month gym membership + 3 sessions/wk supervised by personal trainer) compared to a low resource intervention (unsupervised home-based program prescribed while in hospital) delivered better adherence and dosage of training. Patient-level outcomes were not different between groups (Hassett 2009).
• Costs are likely to be at least moderate.

BRIDGES audit of brain injury services:

BRIDGES audit study for adult and older adult brain injury rehabilitation services across Australia (n=21): Number of sites who have the following equipment for aerobic training in inpatient and/or outpatient services: Treadmill (95%), Cross trainer (29%), Cycle ergometer (76%), Arm ergometer (57%), MOTOmed™ (52%), Stepper (24%), Recumbent Stepper (10%), HR Monitor (76%).

BRIDGES qualitative research with people living with TBI:

This work provided insights into costs for aerobic training in the community:

Costs of physical activities, transport and equipment and, primarily, variability in insurance coverage, played a very significant role in enabling or obstructing access to different types of physical activity including aerobic training:

I get help by the NDIS [National Disability Insurance Scheme], so that is a major factor in what exercise I choose to do…. I wouldn't have an exercise physiologist … coming to my house if we weren't getting help. I can guarantee, that's a big deal…. we couldn't afford to be supporting exercise physiology and the gym and all the other stuff if we weren't getting help. (P3)

Whereas for others, especially those with higher support needs, it was essential to find an activity, often with a facilitator, that was more attuned to their needs:</td><td>Nil.</td></tr>
</table>

	I need a personal trainer because my body is stronger than my brain. So if I didn't have the safety requirements of the personal trainer guide me through- yesterday with the leg press machine I did a hundred reps of 250 kilos and I couldn't do that on my own, because first I couldn't load up the machine with five 20 kilo plate from each side. (P20) **BRIDGES qualitative research with stakeholder groups:** It was noted from multiple stakeholders the need for attendant care workers to support participation in physical activity (including aerobic training) including supporting travel, motivation to do the activity, supervision of home or gym programs. It was noted from health professional and community physical activity providers, that specialised/adapted equipment is needed for those with higher support needs that either needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment.	

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies include cost data about the resources required.	Nil.

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Favors the comparison ○ Probably favours the comparison ○ Does not favour either the intervention or the comparison ○ Probably favours the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Nil.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	• General population studies have shown lower physical activity levels (with most likely lower cardiorespiratory fitness levels) in those with lower socioeconomic status (Jerome 2023). Providing an intervention to increase aerobic fitness for adults with TBI will likely increase equity in more disadvantaged groups. • Access to inpatient rehabilitation services is within public health system, so access for all is dependent on need, not funding. It is worth noting specialist adult brain injury services typically have an admission criterion of working age (15-65 years), thus older adults sustaining a TBI (which is on the rise due to ageing population and falls in older adults; Gardner 2018) may be admitted to general rehabilitation unit who may not prioritise these guidelines for small number of TBI patients. • There is likely access to state-based funding and national disability insurance funding (if <65 years) for any adults with moderate to severe injury (if they meet inclusion criteria) to support aerobic exercise post inpatient rehabilitation. Completion of forms etc for access to these funding schemes may be more challenging for those with lower socioeconomic backgrounds or less family support. • National guidelines may support providers to deliver and funders to fund aerobic exercise for those living in more regional, rural, and remote areas that aren't as linked in with metropolitan specialist brain injury services.	Nil.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	**Evidence from TBI studies:** • Drop-out rates varied across studies but were not significantly different between intervention and control groups and overall were not high. • Adherence to aerobic training intervention was generally good, ranging from 100% attendance (community-based supervised aquatic exercise program - Driver 2004; 2006; 2009) to 44%	Nil.

	(unsupervised home-based program - Hassett 2009). Adherence appeared better when supervision was provided. **BRIDGES audit of brain injury services:** • Twenty-one services delivering rehabilitation to adults and/or older adults with msTBI were audited across Australia. Seven services provided rehabilitation for only working age adults and the remaining 14 provided rehabilitation for both working age adults as well as older adults. The location of the services were across all states and territories of Australia; 17 major cities, 2 regional and 2 outer regional or remote. Fourteen services were public, 3 were private, and 4 were mixed. Eight services were specialist brain injury services with inpatient wards; 6 were private practices that work with TBI clients; 3 were inpatient rehabilitation services that manage some brain injury clients; 2 were outpatient community rehabilitation teams; 1 was a specialist brain injury service for transition/case management; and 1 was an acute neurosurgical ward. • All 21 adult services reported delivering aerobic exercise prescribed or delivered by a physiotherapist. Eight services also utilised an exercise physiologist, and three services utilised allied health assistants or recreational therapists in the delivery of aerobic exercise. **BRIDGES qualitative research with stakeholder groups:** In relation to acceptability of the WHO guideline level of aerobic exercise (150-300min moderate to vigorous physical activity), all stakeholder groups were overall accepting of this but identified that some with more severe injuries (cognitive, behavioural and/or physical impairments) may not be able to meet this level (intensity and/or duration) or may need additional support/equipment to achieve this. It was suggested resources that provide examples of how a range of different people with TBI meet these levels (and how to define moderate intensity activity) would be useful. It was also noted that the good practice points of the WHO guideline were very important. '*In theory it makes sense, but 300 minutes is a big amount. It's a big chunk of time for someone that has a high level of physical disability. And I think it's important to set people up to be able to succeed and achieve.* (Exercise provider) *"... maybe if you could write some case studies or give some examples. Like for example, ... even if the four of us were willing to give our own story about what have we done, then there'll be a case study, for example, three or four case studies. And I guess if you could pick out different people, then you'd have different experiences or something like that. So just so that people could actually see whatever their experiences they could see different ways of doing it."* (Adult with TBI)	
Feasibility Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Aerobic exercise seems feasible in rehabilitation settings when delivered or supervised by health professionals. There are inconsistencies in the current delivery e.g., less than half of the services (9/21) reported conducting a fitness test to set the training parameters; of those six reported using a protocol to test aerobic fitness. Most (81%; 17/21) of the sites monitored intensity of exercise, most commonly by Rating of Perceived Exertion (12/17) or heart rate (10/17). Twelve of the 21 sites (57%) referred their clients to an external provider for aerobic exercise, most commonly to community physiotherapists or exercise physiologists. Almost all the services trained family/support workers to supervise aerobic exercise (19/21), though the frequency varied (11 sometimes, 7 frequently, 1 always). Services reported resources (13/21), time (11/21) and safety (7/21) as the most common barriers to providing aerobic exercise. **Indirect evidence:** Implementation issues have been raised in stroke rehabilitation. For example, a qualitative study (conducted in Canada) embedded in a randomised controlled trial of high intensity aerobic exercise during inpatient rehabilitation raised various implementation considerations (Connell 2018). This study found generally positive experiences of therapists and patients regarding high-intensity aerobic interventions. However, therapists indicated they would adapt the set protocol to accommodate their beliefs about ensuring movement quality. The Canadian guideline requirement for all patients to have an exercise test prior to commencing aerobic exercise and the use of heart rate monitors gave therapists confidence to push patients harder than they normally would. However, the ability to coordinate system and staff to deliver the required exercise test prior to commencing aerobic exercise was a barrier to implementation. **BRIDGES qualitative research with stakeholder groups:** Delivering aerobic exercise in community settings may require specific resources (e.g., equipment, staff) and appropriate opportunities (e.g., inclusive or disability specific facilities and programs). Funding from state-based funders or National Disability Insurance Scheme (NDIS) may support this, however it would need to meet legislative requirements, fit within participant-developed goals and require submission of paperwork. Several stakeholders indicated challenges for individuals with more severe injuries being able to exercise at moderate intensity, and wanted examples of how others have managed to exercise at that intensity: *"I go to the gym with them and try and push them pretty hard, but due to their impairments and whatever else may be going on, it's really hard for them to get to that level. So yeah, I do think that the intensity component of that is probably something that is most challenging to meet."* (Health Professional) *"I think the biggest thing with them is getting somebody to work so much that they huff and puff, is that they can't coordinate their movement and et cetera, well enough to get to that stage."* (Health Professional) *"there's no way he could walk and get his heart rate up. But we got him a bike. I think he bought it himself probably. A recumbent bike, exercise bike, and that worked quite well with him and with encouragement he could work harder on that than he can certainly walking."* (Health Professional)	Health services may not have procedures and staff with knowledge and skills to conduct a fitness test. Fitness testing protocols have been validated in TBI (Hassett 2007). In this study the modified 20m shuttle test and treadmill individualised protocol were compared. A high correlation was observed between the modified shuttle test and treadmill test for VO2peak, peak heart rate and maximal velocity ($r=0.96$, $p<0.001$; $r=0.80$, $p<0.001$; $r=0.82$, $p<0.001$; respectively). A poor correlation was observed between tests for rate of perceived exertion ($r=0.013$, $p=0.952$).

	"... maybe if you could write some case studies or give some examples. ......And I guess if you could pick out different people, then you'd have different experiences or something like that. So just so that people could actually see whatever their experiences they could see different ways of doing it." (Individual with TBI) *"I think examples would definitely be ... so people understand that more and what sort of level of exercise, what sort of activities go with each of those. "* (Family member of person with TBI) *".. I would like to see is probably some suggestions or recommendations for extremely severe TBI. For example, I have a couple who are in sort of a persistent vegetative state and there's no real clear guidance on what's going to be appropriate"* (Service funder)	

SUMMARY OF FINDINGS TABLE

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured aerobic exercise training	control	Relative (95% CI)	Absolute (95% CI)		
Cardiorespiratory fitness at end of intervention (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 11.2 weeks; assessed with: VO2 (2 studies), Watts (3 studies) peak fitness test; higher is better)												
5	randomised trials	serious[a]	not serious	not serious	serious[b]	none[c]	53	46	-	SMD **0.53 SD higher** (0.95 higher to 0.11 higher)	⊕⊕◯◯ Low	CRITICAL
Cardiorespiratory fitness at end of follow-up (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 24 weeks; assessed with: Peak power output (Watts); higher is better)												
1	randomised trials	serious[d]	not serious	not serious	very serious[e]	none	19	21	-	MD **3.27 Watts higher** (34.21 lower to 40.75 higher)	⊕◯◯◯ Very low	CRITICAL
Cardiorespiratory fitness at end of intervention (fitness centre-based fitness training with supervision vs. home-based fitness training without supervision) (follow-up: mean 12 weeks; assessed with: Modified 20m shuttle test, maximal velocity, m/sec; higher is better)												
1	randomised trials	not serious	not serious	not serious	very serious[e]	none	32	30	-	MD **0.7 m/sec lower** (1.55 lower to 0.15 higher)	⊕⊕◯◯ Low	CRITICAL
Cardiorespiratory fitness at end of follow-up (fitness centre-based fitness training with supervision vs. home-based fitness training without supervision) (follow-up: mean 24 weeks; assessed with: Modified 20m shuttle test, maximal velocity, m/sec; higher is better)												
1	randomised trials	not serious	not serious	not serious	very serious[e]	none	32	30	-	MD **0.8 m/sec lower** (1.7 lower to 0.1 higher)	⊕⊕◯◯ Low	CRITICAL
Comorbidities and mortality - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	CRITICAL
Walking capacity (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 11 weeks; assessed with: Six-minute walk test (metres); higher is better)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured aerobic exercise training	control	Relative (95% CI)	Absolute (95% CI)		
2	observational studies	very serious[f]	not serious	not serious	very serious[g]	none[f]	**Hoffman 2010:** · Aerobic training group (n=37): Baseline: 409.35m; End of intervention: 454.5m (11% mean improvement). Waitlist control group (n=39): Baseline: 387.7m; End of intervention: 425.5m (9.7% mean improvement). **Ding 2022:** Data not clearly presented to be useful. 5/10 participants in aerobic training group had improved walking capacity on 6MWT with 4.6 to 7.1% increase of 6MWT. Only 2/10 participants in stretching control group had an improvement in walking capacity (5% and 25.8%).				⊕◯◯◯ Very low	CRITICAL
Combined mobility (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 10 weeks; assessed with: Performance-based tests (BBS Bateman (RCT- full ABI sample); HiMAT Damiano (non-RCT)); higher is better)												
2	observational studies	very serious[h]	not serious	not serious	very serious[e]	none[h]	**Bateman 2001** (full ABI dataset): Aerobic training gp (n=69); Control relaxation gp (n=71) MD (95%CI) on BBS (0 to 56 points): 1,8 (-2.66 to 6.26) **Damiano 2016** (single group n=9) Mean (SD) HiMAT (max score 54 points) Baseline: 35.7 (7.4); End intervention: 34.3 (7.8)				⊕◯◯◯ Very low	CRITICAL
Physical activity (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 10 weeks; assessed with: Exercise recall, total mins per week & number of days per week; higher is better)												
1	randomised trials	serious[d]	not serious	not serious	very serious[g]	none	**Hoffman 2010 (2nd paper Wise 2012- follow-up intervention gp only):** **Exercise recall total minutes per week:** ·Aerobic training group : o Baseline: 66mins/wk (n=40) o End of intervention: 252mins/wk (281% mean improvement) (n=37) o 6month follow-up (intervention group only): 147 (SD185) mins/wk (n=29) ·Waitlist control group: o Baseline: 58mins/wk o End of intervention: 143m (147% mean improvement) **Exercise recall number of days per week:** · Aerobic training group: o Baseline: 1.28 days/week o End of intervention: 3.68 days/week (188% mean improvement) o 6month follow-up (intervention group only): 2.31 (SD2.6) days/wk (n=29) · Waitlist control group: o Baseline: 1.47 days/week o End of intervention: 2.05 days/week (39% mean improvement)				⊕◯◯◯ Very low	IMPORTANT
Body composition (SMD) at end of intervention (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 10 weeks; assessed with: BMI (Bateman 2001) and Percentage bodyfat (Driver 2004); lower is better)												
2	randomised trials	serious[d]	not serious	not serious	very serious[e]	none	32	29	-	SMD **0.29 SD higher** (0.22 lower to 0.79 higher)	⊕◯◯◯ Very low	IMPORTANT
Body composition (SMD) at end of follow-up (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 24 weeks; assessed with: BMI kg/m2; lower is better)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured aerobic exercise training	control	Relative (95% CI)	Absolute (95% CI)		
1	randomised trials	serious[d]	not serious	not serious	very serious[e]	none	20	21	-	SMD **0.52 SD higher** (0.11 lower to 1.14 higher)	⨁◯◯◯ Very low	IMPORTANT
Body composition at end of intervention period (comparing supervised fitness centre-based program to unsupervised home-based program (follow-up: mean 12 weeks; assessed with: BMI, kg/m2; lower is better)												
1	randomised trials	serious[i]	not serious	not serious	very serious[e]	none	15	13	-	MD **0.5 higher** (2.14 lower to 3.14 higher)	⨁◯◯◯ Very low	IMPORTANT
Mood (SMD) at end of intervention (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 9.2 weeks; assessed with: various depression measures; lower is better)												
5	randomised trials	serious[a]	serious[j]	not serious	very serious[e]	none	115	121	-	SMD **0.37 SD lower** (0.8 lower to 0.05 higher)	⨁◯◯◯ Very low	IMPORTANT
Mood (SMD) at end of intervention (aerobic fitness vs. no intervention or non-active control) (post-hoc: Bateman 2001 removed as inpatient setting and control intervention is relaxation therapy) (follow-up: mean 8.5 weeks; assessed with: various depression measures; lower is better)												
4	randomised trials	serious[a]	not serious	not serious	serious[b]	none	92	102	-	SMD **0.51 SD lower** (0.93 lower to 0.1 lower)	⨁⨁◯◯ Low	IMPORTANT
Mood (SMD) at end of follow up (aerobic fitness vs. no intervention or non-active control) (follow-up: mean 8 weeks; assessed with: various depression measures; lower is better)												
2	randomised trials	serious[d]	serious[j]	not serious	very serious[e]	none	56	57	-	SMD **0.07 SD lower** (0.84 lower to 0.69 higher)	⨁◯◯◯ Very low	IMPORTANT
Mood at end of intervention period (comparing supervised fitness centre-based program to unsupervised home-based program (follow-up: mean 12 weeks; assessed with: DASS depression subscale (0 to 42); lower is better)												
1	randomised trials	serious[i]	not serious	not serious	very serious[e]	none	32	30	-	MD **2 DASS score lower** (6 lower to 2 higher)	⨁◯◯◯ Very low	IMPORTANT
Adverse Events at end of intervention												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured aerobic exercise training	control	Relative (95% CI)	Absolute (95% CI)		
24	observational studies	very serious[k]	not serious	not serious	not serious	publication bias strongly suspected[l]	No SAEs were reported. Five studies reported minor AEs, mostly musculoskeletal. Two participants in one study (pre-post) reported ankle soreness and DOMS). One study (RCT) reported one withdrawal due to muscle pain and fatigue. One study (case series) reported one participant experiencing nausea and one light-headedness after training. One RCT which monitored AEs in both groups reported more AE in fitness group vs. home group (ARR –0.2, 95% CI –0.4 to 0.0). Six AE in fitness group (Three participants reported musculoskeletal pains, one reported occasional blurred vision after a session, one reported restriction on social outings with friends, and one reported feelings of depression because of poor physical state and being unable to fund ongoing fitness centre membership)				⨁◯◯◯ Very low	CRITICAL

CI: confidence interval; **MD:** mean difference; **SMD:** standardised mean difference

EXPLANATIONS

a. Allocation concealment missing in majority of studies. Blinding not possible participants and therapists for all studies. No published protocols or trial registration to determine if all outcomes reported for all studies.

b. Small sample size. CI wide but ranging from small to large positive effect.

c. No studies have published protocols or trial registration listed in their papers. Unable to determine if all outcomes reported.

d. Blinding not possible participants and therapists. No published protocol or trial registration to determine if all outcomes reported for study.

e. Small sample size. CIs very wide, ranging from favouring aerobic training intervention to favouring the control intervention.

f. 1 RCT + 1 non-RCT. Neither present full data (mean, SD) to enable calculation of MD.

g. Small sample size. Estimate of variability not provided.

h. 1 RCT + 1 non- RCT.

i. Blinding not possible participants and therapists. Self-report outcome

j. MD varies from favouring intervention to favouring control. I2 is high.

k. Mix of RCTs and non-RCTs. Not all studies explicitly mentioned AEs so minor adverse events may have occurred but were not measured.

FOREST PLOTS AND RISK OF BIAS ASSESSMENT

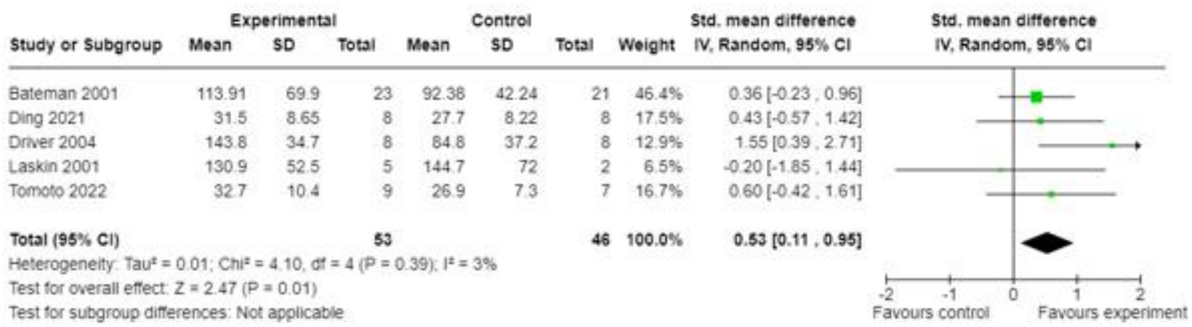
Outcome: Cardiorespiratory fitness

Cardiorespiratory fitness at end of intervention: (aerobic fitness vs. no intervention or non-active control)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bateman 2001	+	+	-	+	?	+	-	+
Ding 2021	+	-	-	+	+	+	-	+
Driver 2004	+	-	-	+	+	+	-	+
Laskin 2001	+	+	-	-	+	+	-	+
Tomoto 2022	+	-	-	+	+	+	-	+

- Forest plot (from Hassett 2023, JOP):



Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. mean difference IV, Random, 95% CI
Bateman 2001	113.91	69.9	23	92.38	42.24	21	46.4%	0.36 [-0.23 , 0.96]
Ding 2021	31.5	8.65	8	27.7	8.22	8	17.5%	0.43 [-0.57 , 1.42]
Driver 2004	143.8	34.7	8	84.8	37.2	8	12.9%	1.55 [0.39 , 2.71]
Laskin 2001	130.9	52.5	5	144.7	72	2	6.5%	-0.20 [-1.85 , 1.44]
Tomoto 2022	32.7	10.4	9	26.9	7.3	7	16.7%	0.60 [-0.42 , 1.61]
Total (95% CI)			**53**			**46**	**100.0%**	**0.53 [0.11 , 0.95]**

Heterogeneity: Tau² = 0.01; Chi² = 4.10, df = 4 (P = 0.39); I² = 3%
Test for overall effect: Z = 2.47 (P = 0.01)
Test for subgroup differences: Not applicable

Conversion SMD to MD (95%CI) Peak power output (3 studies used): 16.2 (2.4 to 29.1) Watts

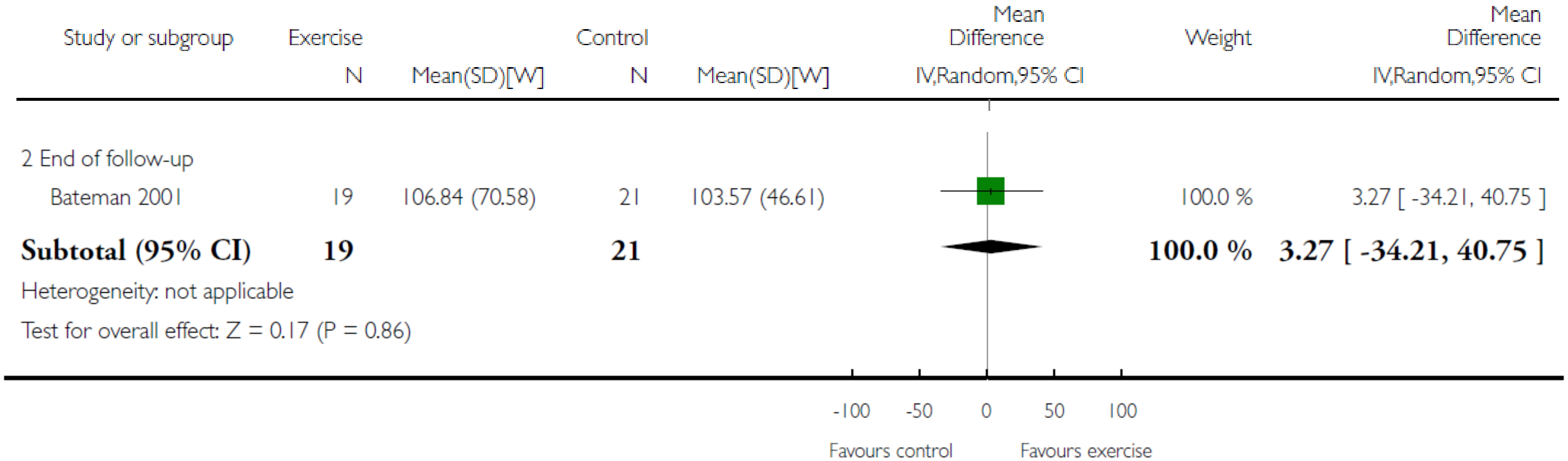
Conversion SMD to MD (95%CI) Peak oxygen uptake (2 studies used): 3.9 (0.8 to 7.1) ml/kg/min

Cardiorespiratory fitness at end of follow-up: (aerobic fitness vs. no intervention or non-active control)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bateman 2001	+	+	-	+	?	+	-	+

- Forest plot (from Hassett 2017, Cochrane review):



MD (95%CI) peak power output (Watts): 3.3 (-34.2 to 40.8).

Cardiorespiratory fitness at end of intervention and follow-up: (comparing two different aerobic training interventions)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Hassett 2009	+	+	-	+	?	+	+	+

Fitness centre-based fitness training with supervision vs. Home-based fitness training without supervision (Hassett 2009 *J Rehabil Med*)

Table II. *Group data and between-group differences for primary and secondary physical outcomes and goal attainment*

Variable	Time	Fitness centre group n	Fitness centre group Mean (SD)	Home group n	Home group Mean (SD)	Mean between-group difference (95% CI)*	p-value†
Primary physical outcomes							
Maximal velocity, m/sec	Baseline	32	6.8 (1.5)	30	7.6 (1.6)		
	End of intervention	32	7.8 (1.8)	30	8.5 (1.6)	0.0 (–0.6 to 0.6)	0.966
	Follow-up	32	7.9 (1.9)	30	8.7 (1.7)	–0.2 (–0.9 to 0.5)	0.542

- Maximal velocity measured on a modified 20 metre shuttle test. * ANCOVA adjusted.

Non-ANCOVA adjusted maximal velocity (m/s) end of intervention: -0.70 (-1.55 to 0.15) (favours home-based)

Non-ANCOVA adjusted maximal velocity (m/s) end of follow-up: -0.80 (-1.70 to 0.10) (favours home-based)

Outcome: Morbidity and Mortality

- No studies have measured this outcome.

Outcome: Walking capacity

Two studies measured walking capacity on 6MWT; 1 RCT (Hoffman 2010) and 1 nRCT (Ding 2022). Neither study provided data sufficient to evaluate mean difference.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Hoffman 2010	+	+	-	+	?	+	-	+
Ding 2022	-	-	-	-	-	+	-	+

Hoffman 2010: Six minute walk test

- Aerobic training group:
  - Baseline: 409.35m
  - End of intervention: 454.5m (11% mean improvement)
- Waitlist control group:
  - Baseline: 387.7m
  - End of intervention: 425.5m (9.7% mean improvement)

Ding 2022:

Data not clearly presented to be useful. Five out of 10 participants in aerobic training group had improved walking capacity on 6MWT with 4.6–7.1% increase of 6MWT. Only 2 out of 10 participants in stretching control group had an improvement in walking capacity (5% and 25.8%).

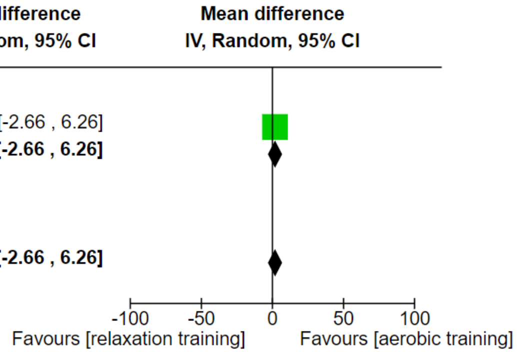
Outcome: Combined mobility

- Risk of bias:

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bateman 2001	+	+	-	+	?	+	-	+
Damiano 2016	-	-	-	-	-	+	-	+

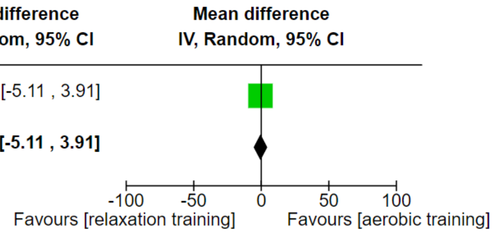
- End of intervention: (full Bateman dataset ABI) Berg Balance Scale (0 to 56 points)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean difference IV, Random, 95% CI
2.1.1 End of intervention								
Bateman (full dataset)	46.5	12.8	69	44.7	14.1	71	100.0%	1.80 [-2.66 , 6.26]
Subtotal (95% CI)			**69**			**71**	**100.0%**	**1.80 [-2.66 , 6.26]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.79 (P = 0.43)								
Total (95% CI)			**69**			**71**	**100.0%**	**1.80 [-2.66 , 6.26]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.79 (P = 0.43)								
Test for subgroup differences: Not applicable								



- End of follow-up: (full Bateman dataset ABI) Berg Balance Scale (0 to 56 points)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean difference IV, Random, 95% CI
Bateman (full dataset)	46.7	13.2	60	47.3	12.1	61	100.0%	-0.60 [-5.11 , 3.91]
Total (95% CI)			**60**			**61**	**100.0%**	**-0.60 [-5.11 , 3.91]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.26 (P = 0.79)								
Test for subgroup differences: Not applicable								



- Pre-post values for TBI group on High level Mobility Assessment Scale (HiMAT) (max score 54 points)
  - Damiano 2016: n=9

- Pre-test: 35.7 (7.4)
- Post-test: 34.3 (7.8)

Outcome: Physical activity

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Hoffman 2010	+	+	-	+	?	+	-	+

Exercise recall total minutes per week:

- Aerobic training group:
  - Baseline: 66mins/wk (n=40)
  - End of intervention: 252mins/wk (281% mean improvement) (n=37)
  - 6month follow-up (intervention group only- Wise 2012): 147 (SD185) mins/wk (n=29)
- Waitlist control group:
  - Baseline: 58mins/wk
  - End of intervention: 143m (147% mean improvement)

Exercise recall number of days per week

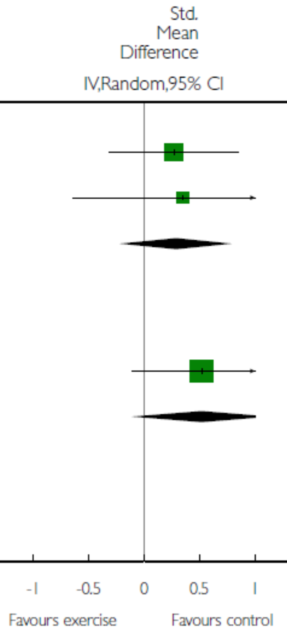
- Aerobic training group:
  - Baseline: 1.28 days/week
  - End of intervention: 3.68 days/week (188% mean improvement)
  - 6month follow-up (intervention group only- Wise 2012): 2.31 (SD2.6) days/wk (n=29)
- Waitlist control group:
  - Baseline: 1.47 days/week
  - End of intervention: 2.05 days/week (39% mean improvement)

Outcome: Body Composition

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bateman 2001	+	+	-	+	?	+	-	+
Driver 2004	+	-	-	+	+	+	-	+

(From Hassett 2017, Cochrane review):

Study or subgroup	Exercise N	Mean(SD)	Control N	Mean(SD)	Weight	Std. Mean Difference IV,Random,95% CI
1 End of intervention						
Bateman 2001	24	25.84 (3.11)	21	24.83 (4.36)	73.9 %	0.27 [-0.32, 0.85]
Driver 2004	8	18.4 (3.3)	8	16.8 (5.1)	26.1 %	0.35 [-0.64, 1.34]
Subtotal (95% CI)	**32**		**29**		**100.0 %**	**0.29 [-0.22, 0.79]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.02$, df = 1 (P = 0.88); $I^2 = 0.0\%$						
Test for overall effect: Z = 1.12 (P = 0.26)						
2 End of follow-up						
Bateman 2001	20	27.11 (3.2)	21	25.05 (4.49)	100.0 %	0.52 [-0.11, 1.14]
Subtotal (95% CI)	**20**		**21**		**100.0 %**	**0.52 [-0.11, 1.14]**
Heterogeneity: not applicable						
Test for overall effect: Z = 1.62 (P = 0.10)						
Test for subgroup differences: $Chi^2 = 0.31$, df = 1 (P = 0.58), $I^2 = 0.0\%$						



Comparing two different aerobic training interventions:

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Hassett 2009	+	+	-	+	?	+	+	+

(Hassett 2009 *J Rehabil Med*)

Variable	Time	Fitness centre group		Home group		Mean between-group difference (95% CI)*	*p*-value†
		n	Mean (SD)	*n*	Mean (SD)		
BMI, kg/m²	Baseline	15	24.0 (3.5)	12	22.3 (3.8)		
	End of intervention	15	23.9 (3.5)	13	23.4 (3.6)	–0.7 (–2.1 to 0.8)	0.347
	Follow-up	18	24.7 (3.8)	16	23.2 (3.6)	–0.4 (–2.1 to 1.4)	0.678
WHR	Baseline	14	0.87 (0.06)	12	0.86 (0.06)		
	End of intervention	15	0.88 (0.06)	12	0.90 (0.05)	–0.02 (–0.06 to 0.02)	0.286
	Follow-up	18	0.87 (0.06)	17	0.88 (0.05)	–0.02 (–0.05 to 0.01)	0.267
Waist circumference, cm	Baseline	14	83.5 (8.8)	12	81.1 (9.6)		
	End of intervention	15	83.6 (8.7)	12	82.4 (10.2)	0.17 (–3.1 to 3.5)	0.916
	Follow-up	18	84.3 (9.2)	17	81.1 (9.4)	0.84 (–3.0 to 4.7)	0.651

* ANCOVA adjusted values.

Non-ANCOVA adjusted value end of intervention BMI = 0.50 (-2.14 to 3.14) (favours home-based group)

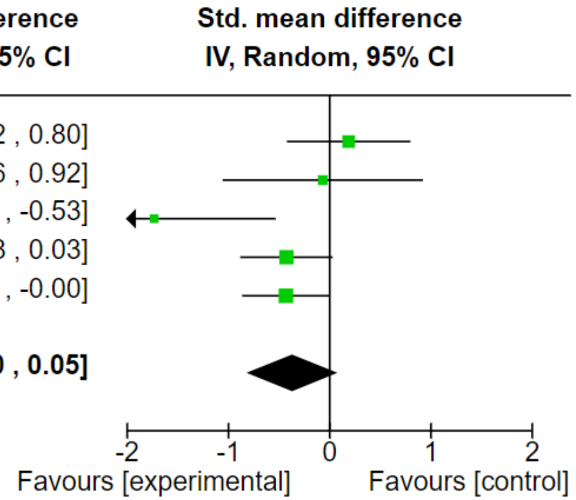
Outcome: Mood

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bateman 2001	+	+	-	+	?	+	-	+
Ding 2021	+	-	-	+	+	+	-	+
Driver 2009	+	-	-	+	+	+	-	+
Hoffman 2010	+	+	-	+	?	+	-	+
McMillan 2002	?	-	-	+	?	-	-	+

	Experimental			Control				Std. mean difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Bateman 2001	5.43	4.39	23	4.63	3.92	19	22.0%	0.19 [-0.42 , 0.80]
Ding 2021	49	12.95	9	50	14.8	7	12.6%	-0.07 [-1.06 , 0.92]
Driver 2009	0.25	0.26	8	1.11	0.61	8	9.5%	-1.73 [-2.93 , -0.53]
Hoffman 2010	16.4	10.1	37	21.2	12	39	27.5%	-0.43 [-0.88 , 0.03]
McMillan 2002	4	4	38	6	5	48	28.4%	-0.43 [-0.86 , -0.00]
Total (95% CI)			**115**			**121**	**100.0%**	**-0.37 [-0.80 , 0.05]**

Heterogeneity: Tau² = 0.12; Chi² = 8.67, df = 4 (P = 0.07); I² = 54%
Test for overall effect: Z = 1.72 (P = 0.08)
Test for subgroup differences: Not applicable



End of intervention (post-hoc with Bateman 2001 removed- inpatient setting and control intervention is relaxation therapy)

- Risk of bias

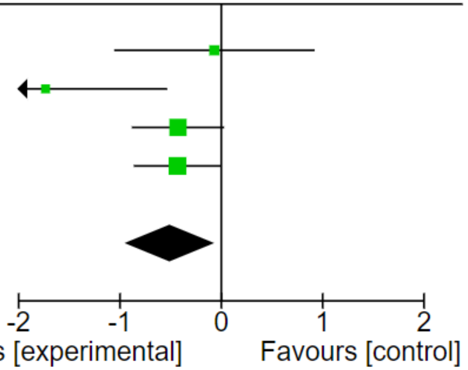
	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Ding 2021	+	-	-	+	+	+	-	+
Driver 2009	+	-	-	+	+	+	-	+
Hoffman 2010	+	+	-	+	?	+	-	+
McMillan 2002	?	-	-	+	?	-	-	+

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. mean difference IV, Random, 95% CI
Ding 2021	49	12.95	9	50	14.8	7	14.0%	-0.07 [-1.06 , 0.92]
Driver 2009	0.25	0.26	8	1.11	0.61	8	10.2%	-1.73 [-2.93 , -0.53]
Hoffman 2010	16.4	10.1	37	21.2	12	39	37.0%	-0.43 [-0.88 , 0.03]
McMillan 2002	4	4	38	6	5	48	38.8%	-0.43 [-0.86 , -0.00]
Total (95% CI)			**92**			**102**	**100.0%**	**-0.51 [-0.93 , -0.10]**

Heterogeneity: $Tau^2 = 0.07$; $Chi^2 = 4.96$, df = 3 (P = 0.17); $I^2 = 40\%$

Test for overall effect: Z = 2.41 (P = 0.02)

Test for subgroup differences: Not applicable

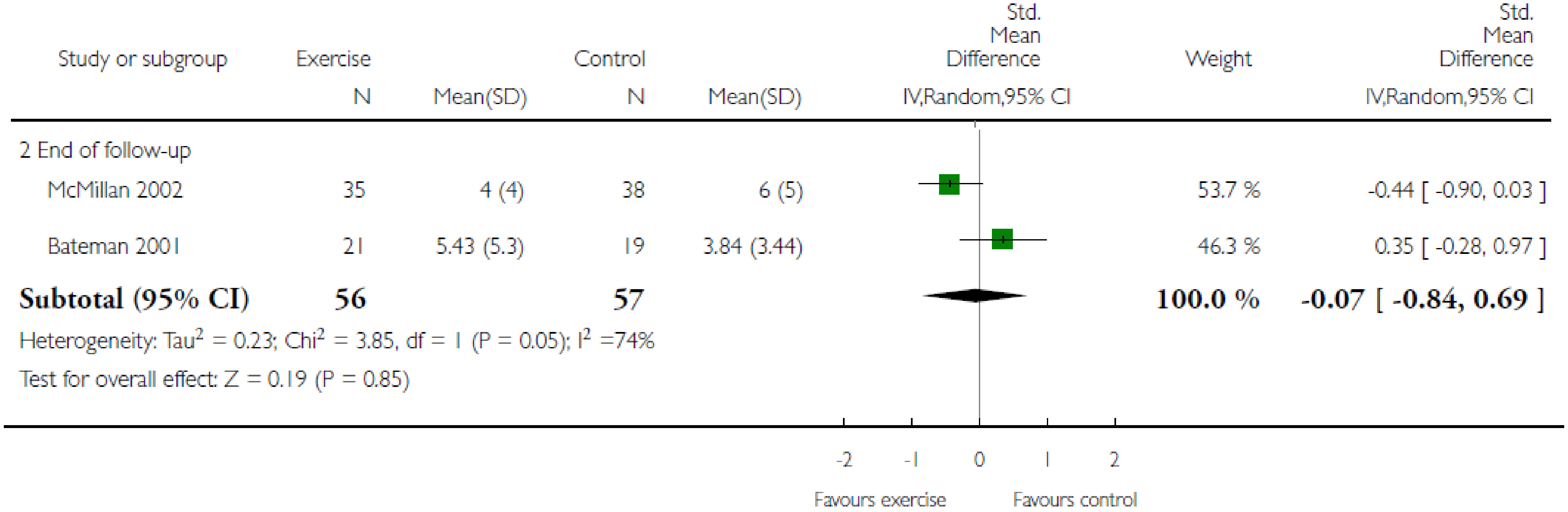


Mood at end of follow-up:

	Random sequence	Allocation concealment (selection bias)	Blinding of participants and personnel	Blinding of outcome assessment	Blinding of outcome assessment	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias

	generation (selection bias)		(performance bias)	(detection bias): Objective outcomes	(detection bias): Subjective outcomes			
Bateman 2001	+	+	-	+	?	+	-	+
McMillan 2002	?	-	-	+	?	-	-	+

(From Hassett 2017, Cochrane review):



- Hoffman 2010 (published intervention group follow up data only – Wise 2012): At 6 months, intervention group score on Beck Depression Index = 16.0 (11.9); n=32 [Baseline 21.7 (9.2); n=40; End of intervention 16.5 (10.3) n=37].

Mood at the end of intervention and end of follow-up period (comparing two different aerobic training interventions) (Hassett 2009 *J Rehabil Med*)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Hassett 2009	+	+	-	+	?	+	+	+

(Hassett 2009 *J Rehabil Med*)

Table III. *Group data and between-group differences for secondary outcomes of psychological functioning*

Variable	Time	Fitness centre group $n=32$	Home group $n=30$	Mean between-group difference (95% CI) $n=62$*	p-value†
DASS depression subscale (0–42)	Baseline	1 (0–5)	1 (0–2)		
	End of intervention	5 (0–11)	1 (0–3)	–2 (–6 to 2)	0.238
	Follow-up	5 (0–12)	1 (0–6)	–1 (–5 to 3)	0.532
POMS depression-dejection domain (32–75)	Baseline	40 (6)	39 (5)		
	End of intervention	41 (7)	39 (7)	2 (–2 to 5)	0.334
	Follow-up	41 (6)	40 (6)	1 (–2 to 4)	0.579

Outcome: Adverse Events

Study	Design	Mode of training	Adverse Events
Bateman 2001	RCT	Cycle ergometer	None reported.
Chin 2015	Pre-Post	Treadmill	No SAE. Two overtraining (ankle soreness, DOMS)
Chin 2015	Pre-Post	Treadmill	No SAE. Several subjects experienced minor and reversible self-limiting musculoskeletal issues such as muscle soreness and mild medial tibial stress syndrome (shin splints)
Damiano 2016	non-RCT	Elliptical	None reported
Dault 2002	non-RCT	Dance	None reported
Devine 2016	Pre-Post	Choice local gym	None reported
Ding 2022	non-RCT	Choice local gym	None reported

Ding 2021	RCT	Choice local gym	No SAE. One withdrawal aerobic group due to muscle pain & fatigue
Grealy 1999	Pre-Post	Cycle ergometer	None reported
Hoffman 2010	RCT	Choice	None reported
Lee 2014	non-RCT (waitlist control)	Aerobic exercise with affirmations	None reported
Lilliecreutz 2017	Pre-Post	Outdoor walking	None reported
McMillan 2002	RCT	Basic fitness exercise, no equipment	None reported
Morris 2018	case series	MOTOmed^{TM}, cycle ergometer	No SAE. 2 AEs- nausea after one session & light headed after one session
Schwandt 2012	Pre-Post	Cycle ergometer, treadmill, or recumbent stepper	None reported
Tomoto 2022	RCT	Choice local gym	None reported
Weinstein 2017	Pre-Post	Treadmill	None reported
Wender 2021	RCT	Cycle ergometer	None reported
Wolman 1994	Pre-Post	Cycle ergometer	None reported
Multicomponent studies			
Driver 2009	RCT	Aquatic exercise	None reported
Driver 2004	RCT	Aquatic exercise	None reported
Driver 2006	RCT	Aquatic exercise	None reported
Hassett 2009	RCT	Fitness centre (choice, include treadmill) vs. home walking program	No SAE. More AE in fitness group vs. home group (ARR –0.2, 95% CI –0.4 to 0.0). Six AE in fitness group- (Three participants reported musculoskeletal pains, one reported occasional blurred vision after a session, one reported restriction on social outings with friends, and one reported feelings of depression because of poor physical state and being unable to fund ongoing fitness centre membership)
Hassett 2012	RCT	Circuit class, 10 different stations	None reported

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Clinical question 2: Aerobic exercise training for children and adolescents with moderate to severe traumatic brain injury

Clinical question

Should structured **aerobic exercise** training compared to control be used for **children and adolescents** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home
- Schools

Perspective: Health systems

Outcomes of interest:

1.	Cardiorespiratory fitness	CRITICAL
2.	Co-morbidities and mortality	CRITICAL
3.	Walking capacity	IMPORTANT
4.	Combined mobility	IMPORTANT
5.	Physical activity	IMPORTANT
6.	Body composition	IMPORTANT
7.	Mood	IMPORTANT

Conditional recommendation:

For children and adolescents after moderate to severe traumatic brain injury, we suggest regular energetic play and/or exercise that is individually-tailored and across the continuum of care.

Good practice points:
We suggest:

- Energetic play and/or exercise aims to achieve participation-level goals established collaboratively where the child's voice is at the centre.
- Energetic play and/or exercise is incorporated into weekly routines and key supports (e.g., siblings, friends, teachers, support workers, and parents) are trained in facilitating this activity.
- Assessment of fitness is conducted for school aged children prior to commencing an energetic play and/or exercise program using a standardised or modified protocol and pre-exercise screening.

- Energetic play and/or exercise is prescribed using the Frequency, Intensity, Time, and Type (FITT) principles according to American College of Sports Medicine guidelines for stroke and brain injury.
- Timing of energetic play and/or exercise considers the impact of fatigue on behaviour and participation in other activities including school.
- Exercise dosage is monitored (preferably using a heart rate monitor) for older children and adolescents when possible.
- Energetic play and/or exercise is transitioned from health settings to community-based physical activity settings where appropriate.

Precautionary Points:

- For children and adolescents on anti-epileptic medication, moderate to high intensity energetic play and/or exercise may increase the risk of seizure if they are medically unwell or not routinely taking their medication.
- When determining intensity of exercise, consider any medication that may influence heart rate or blood pressure.
- In the acute stage of recovery, consider mode of energetic play and/or exercise and seek medical advice prior to commencing energetic play and/or exercise for children and adolescents with additional complications such as orthopaedic injuries or craniotomy.

Justification

Overall justification

Cardiorespiratory deconditioning is a common problem after TBI likely to restrict reintegration back into previous roles within family, friends, school and community. Aerobic training is likely to address this problem.

Detailed justification

Problem

Cardiorespiratory deconditioning is a common secondary physical impairment after TBI which can reduce participation in everyday activities.

Desirable Effects

Very low certainty evidence that children and adolescents with TBI can improve aerobic fitness with variable effects on walking capacity and balance (specificity of training). Adults with TBI: moderate to large effects on fitness and mood (low certainty evidence). Children with CP improved gross motor function (low quality evidence). WHO guidelines: low-certainty evidence of improved physical function in children with intellectual disability and moderate-certainty evidence that moderate to vigorous physical activity can have beneficial effects on cognition, including attention, executive function, and social disorders in children with ADHD.

Balance of effects

Likely desirable effects. Undesirable effects such as adverse events are likely small (e.g., muscle soreness).

Acceptability

Good acceptability from multiple stakeholders.

Feasibility

Feasible to deliver in inpatient and post-rehabilitation settings, although implementation support will be needed, especially for services and clinicians working with children and adolescents with higher support needs.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
DESIRABLE EFFECTS	Trivial	Small	Moderate	Large	**Varies**	Don't know	
UNDESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large	Varies	Don't know	
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High	No included studies		
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High	**No included studies**		
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
FEASIBILITY	No	Probably no	**Probably yes**	Yes	Varies	Don't know	

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

<table>
<tr><td colspan="3">Problem
Is the problem a priority?</td></tr>
<tr><td>JUDGEMENT</td><td>RESEARCH EVIDENCE</td><td>ADDITIONAL CONSIDERATIONS</td></tr>
<tr><td>○ No
○ Probably no
○ Probably yes
● Yes
○ Varies
○ Don't know</td><td>Reduced aerobic fitness is a secondary physical impairment likely to be experienced by children and adolescents after msTBI, particularly if the injury causes a long period of inactivity. A test-retest reliability was conducted for the modified 20m shuttle test in a convenience sample of 19 children with severe TBI (mean SD GCS 5.9 (1.7), aged 8 to 17 yrs, on average 4.2 (SD 2.6) years post injury. The mean (SD); range of shuttle test for the first assessment was 9.16 levels (2); 6 to 15. [Modified 20 m shuttle test is a modification of the commonly known beep test. It is modified by eight additional beginning levels at slower pace and cones at 0, 10m and 20m to assist with timing. This means level 9 on the modified test equals level 1 on the standard beep test]. Comparing fitness results in this cohort to normative values suggest a very reduced level (mean = 29th percentile, range 5th to 95th) of cardiorespiratory fitness in TBI children (Rossi 1996).

Successful reintegration into physical activity such as active play, sport, exercise and recreation is important for children and adolescents after TBI. The ability to play sports and compete with their peers can provide a sense of accomplishment and acceptance. Sufficient cardiorespiratory fitness to participate in active play, sport, exercise and recreation is needed (Rossi 1996).</td><td>Cerebral Palsy (CP):

• Reduced cardiorespiratory fitness is an impairment associated with CP which can result in difficulties performing everyday activities such as dressing, walking and negotiating stairs (Ryan 2017).
• Children and adolescents living with TBI will often be grouped with children with CP for rehabilitation and disability sport and recreation activities under the category of Acquired Brain Injury.
• Although there are similarities between children and adolescents with mild CP and TBI, there are also important differences that need to be considered when considering suitability of evidence in CP for TBI. Some differences include children with CP may have more motor impairments without impairments in executive functioning, and children with TBI may be the opposite.</td></tr>
<tr><td colspan="3">Desirable Effects
How substantial are the desirable anticipated effects?</td></tr>
<tr><td>JUDGEMENT</td><td>RESEARCH EVIDENCE</td><td>ADDITIONAL CONSIDERATIONS</td></tr>
<tr><td>○ Trivial
○ Small
○ Moderate
○ Large
● Varies
○ Don't know</td><td>Evidence in children and adolescents with TBI:

See summary of findings table below. Only one study (non-RCT; Burnfield, 2021) describing three cases of children aged 7, 8 and 9 years old has been conducted in TBI. The three children had severe TBI and participated in 24 sessions of fitness training using a motor-assisted elliptical (ICARE). The three case studies all demonstrated an increase in exercise time over the 24 sessions, similar exercise heart rate for higher intensity longer duration exercise and a reduction in resting heart rate. The case studies also evaluated effect on walking capacity (2MWT distance) and balance (Paediatric Balance Scale 0 to 56) and demonstrated a range of trivial to large improvements across the children and outcomes. No studies measured the other critical and important outcomes we were interested in.</td><td>Cochrane review on exercise interventions in cerebral palsy (Ryan, 2017):

29 included studies (926 participants). Twenty-one trials included people who were able to walk with or without assistive devices, four trials also included people who used wheeled mobility devices in most settings, and one trial included people who used wheeled mobility devices only. Three trials did not report the functional ability of participants. Only two trials reported participants' manual ability. Eight studies compared aerobic exercise to usual care. Two trials compared aerobic exercise to resistance training. There was low-quality evidence that aerobic</td></tr>
</table>

	Evidence in adults with TBI: Four RCTs had an inclusion criteria including adolescents 15 or older due to 15-65 (working age) being an admission criteria for some specialist brain injury units where trials recruited participants. Looking at the mean (SD) of ages in these studies indicates there were none or very few adolescents included (Bateman 2001 [TBI sample only] 34(14); McMillan 2002 31 (13); Hassett 2009 33 (12); Hassett 2012 29 (11)). Moderate to large improvements were demonstrated in cardiorespiratory fitness and moderate effects on reducing depression. No studies evaluated the effect of aerobic training on morbidity and mortality in adults with TBI, and there were mixed and small effects on combined mobility and walking endurance, and trivial or no effect on body composition. Participation in aerobic training program increased overall physical activity (mins per week and number of days per week active) in one study when measured at end of intervention program. The certainty of the evidence of effect for all outcomes was very low. **Evidence from WHO physical activity guidelines for disability (Carty 2021):** • WHO guideline development group considered the evidence for children without disability could be extrapolated for children living with disability for key outcomes including favourable outcomes on cardiorespiratory and muscular fitness, cardiometabolic health, bone health, cognitive outcomes, mental health, and adiposity. • WHO guideline development group considered evidence for physical activity for children living with intellectual disability and children with attention deficit hyperactivity disorder (ADHD). They found low-certainty evidence of improved physical function in children with intellectual disability and moderate-certainty evidence for children with ADHD that moderate to vigorous physical activity can have beneficial effects on cognition, including attention, executive function, and social disorders. The WHO guidelines for children and adolescents (aged 5–17) living with disability recommend: • Children and adolescents living with disability should do at least an average of 60 minutes per day of moderate to vigorous intensity, mostly aerobic, physical activity, across the week. *Strong recommendation, moderate certainty evidence* • Vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone should be incorporated at least 3 days a week. *Strong recommendation, moderate certainty evidence.*	exercise improves gross motor function in the short term (SMD 0.53, 95% CI 0.02 to 1.04, n = 65, 3 studies) and intermediate term (MD 12.96%, 95% CI 0.52% to 25.40%, n = 12, 1 study). Aerobic exercise does not improve gait speed in the short term (MD 0.09 m/s, 95% CI -0.11 m/s to 0.28 m/s, n = 82, 4 studies, very low-quality evidence) or intermediate term (MD -0.17 m/s, 95% CI -0.59 m/s to 0.24 m/s, n = 12, 1 study, low-quality evidence). There is no difference between resistance training and aerobic exercise in terms of the effect on gross motor function in the short term (SMD 0.02, 95% CI -0.50 to 0.55, n = 56, 2 studies, low-quality evidence).

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	No adverse events were reported in the three case studies presented in Burnfield 2021. **Evidence from adults with TBI:** No negative effects found on any of the critical or important outcomes. Adverse events were not explicitly mentioned in all studies. No SAEs were reported in any study. Five studies reported minor adverse events, mostly muscle soreness and fatigue or musculoskeletal pain.	**Clinical expertise input:** Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken. **Medications:** Beta-blockers (e.g., propranolol) are prescribed in TBI rehabilitation to manage post-TBI agitation (mostly adults, not common in children) (Pangilinan, 2010). This can lower heart rate and needs to be taken into consideration if using heart rate to set and monitor training parameters [HRmax pred-adj = 85%(220-age]. Clonidine may be prescribed in children for behaviour regulation, this may lower heart rate. **Cochrane review on exercise interventions in cerebral palsy (Ryan, 2017):** Thirteen trials did not report adverse events, seven reported no adverse events, and nine reported non-serious adverse events.

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	See summary of findings table below, only one study with three participants included. **Evidence from adults with TBI:** All outcomes evaluated were rated as low or very low certainty evidence.	**Cochrane review on exercise interventions in cerebral palsy (Ryan, 2017):** The quality of evidence for all conclusions is low to very low. As included trials have small sample sizes, heterogeneity may be underestimated, resulting in considerable uncertainty relating to effect estimates.

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted in TBI to inform the value people living with TBI place on the main outcomes. **BRIDGES qualitative research with stakeholder groups:** Aerobic exercise in the community that requires the family to drive the activity may be challenging for them to prioritise, particularly if there are other children and activities to juggle. *".... so a person who has mobility issues, the day starts getting out of bed, getting into a chair, or getting ready, getting down the ramp into their house, into their car, driving to wherever they need to go, finding parking. If they need a high ab or something like that to transfer between wheelchairs, their car wheelchair to a beach wheelchair, getting down onto the beach in soft sand, getting into the water, and then the surf might not be cooperating that day and it might be quite dangerous to put somebody in the water, and then participating and then doing all the reverse of that to go home.* (Exercise provider) *"families have got other priorities. So if you gave them that [WHO guideline recommendations] as the guideline, there's no way that they would say that that's something that they would be able to meet, particularly early on in their journey of traumatic brain injury. Maybe many, many years down the track, but definitely not early on.* (Health Professional) *"the ones that have succeeded are the ones where the client is motivated and you can find something really meaningful, salient to that individual. And often they come with that background and then they've got the family who are on board and are able to succeed. And it can be amazing, competitive, high-level athletics, or it can just be these families that they go fishing and they go kayaking and they're doing stuff all the time that's physical, even though it's not at a competitive or athletic level. And I think there's a lot of the children, a lot of family drive as well."* (Health Professional)	If aerobic training can enable the child or adolescent to participate in activities with their peers, it is likely to be of value to them.

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	See summary of findings table below and data in section 2 above (desirable effects). Small undesirable effects and variable desirable effects including potentially large and moderate effects on critical and important outcomes.	Nil.

Resources required

How large are the resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	Cost data is not available from any studies in TBI. The cost of the required resources likely varies depending on the needs of the person with TBI, e.g., if they are able to independently participate in aerobic training, or if they need one-on-one supervision or specific equipment to facilitate aerobic training. **BRIDGES audit of brain injury services:** Six paediatric services across Australia (Location: 3/8 states and territories; all in major cities; 5 public, 1 private; 4 specialist inpatient brain injury rehabilitation, 1 inpatient rehabilitation service that manages some brain injury clients, 1 private practice). Number of sites who have the following equipment for aerobic training in inpatient and/or outpatient services: treadmill (n=5, 83%), cross trainer (n=2, 33%), cycle ergometer (n=4, 67%), arm ergometer (n=1, 17%), MOTOmed^{TM} (n=2, 33%), stepper (n=0), recumbent stepper (n=0), heart rate monitor (n=1, 17%). **BRIDGES qualitative research with people living with TBI:** This work provided insights into costs for aerobic training post-rehabilitation in the community: Costs of physical activities, transport and equipment and, primarily, variability in insurance coverage, played a very significant role in enabling or obstructing access to different types of physical activity including aerobic training: *"I get help by the NDIS, so that is a major factor in what exercise I choose to do…. I wouldn't have an exercise physiologist … coming to my house if we weren't getting help. I can guarantee, that's a big deal…. we couldn't afford to be supporting exercise physiology and the gym and all the other stuff if we weren't getting help."* (P3)	Nil.

	BRIDGES qualitative research with stakeholder groups: It was noted from multiple stakeholders the need for attendant care workers to support participation in physical activity (including aerobic training) including supporting travel, motivation to do the activity, supervision of home or gym programs. *"I find one of the biggest barriers is if they're wanting to get back to community sport or engage in regular exercise that they may have been participating in prior to their injury and are really motivated to get back to that, some of the barriers around access and appropriate equipment, support to be able to get them there, often they're not driving. I think those things become quite difficult, so it's probably more so around appropriate equipment, access and support for transport."* (Health Professional) It was noted from health professional and community physical activity providers, that specialised/adapted equipment is needed for those with higher support needs that either needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment. *"There's a whole range of things, like hand cycling and recumbent bikes are a big passion of mine, so I love adapted bikes, that that's a great way to get people engaged, and that's just on a recreational level, and then we've got that cohort that want to go that little bit further and get classified, and then try to go onto the Paralympics or compete, so cool."* (Health Professional)	
Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies include cost data about the resources required.	Nil.
Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Nil.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	• General population studies have shown lower physical activity levels (with most likely lower cardiorespiratory fitness levels) in lower socioeconomic areas. Providing an intervention to increase aerobic fitness will likely benefit those in more disadvantaged groups. • Access to inpatient rehabilitation services is within public health system, so access for all is dependent on need, not funding. • There is likely access to state-based funding and NDIS for any children and adolescents living with moderate to severe injury (if meet inclusion criteria) to support fitness training post inpatient rehabilitation, but completion of forms etc for access to these funding schemes may be more challenging for those with lower socioeconomic backgrounds or less family support. • National guidelines may support providers to deliver and funders to fund aerobic training for those living in more regional, rural and remote areas that aren't as linked in with specialist brain injury services.	Nil.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Looking more closely at paediatric services, five of the six sites (83%) provided aerobic training, all delivered by physiotherapists, except for one site that also delivered aerobic training by exercise physiologists and/or allied health assistants in addition to physiotherapists. None of the paediatric sites conducted aerobic fitness tests to set training parameters. Three of the 5 sites providing aerobic training monitored intensity, either by observation or rating of	Nil.

	perceived exertion. Four of the 6 sites (67%) refer to external providers for aerobic training, either to another physiotherapist or an exercise physiologist. The same amount of services train family/support workers to supervise aerobic training though the frequency differed (2/4 frequently, 2/4 sometimes). **BRIDGES qualitative research with stakeholder groups:** In relation to acceptability of the WHO guideline level of aerobic exercise (60min per day moderate to vigorous physical activity), all stakeholder groups were overall accepting of this but identified that some with more severe injuries (cognitive, behavioural and/or physical impairments) may not be able to meet this level (intensity and/or duration) or may need additional support/equipment to achieve this. It was suggested resources that provide examples of how a range of different people with TBI meet these levels (and how to define moderate intensity activity) would be useful. It was also noted that the good practice points of the WHO guideline were very important. *"I would discuss being physically active on every day, pick and choose elements of that. I wouldn't rarely talk about the number of minutes or intensity at the stage with most of my clients, but sitting less, moving more, those types of more general principles. Similarly to the second page, I might use something that's more like that. Yeah."*(Health Professional) *"families have got other priorities. So if you gave them that as the guideline, there's no way that they would say that that's something that they would be able to meet, particularly early on in their journey of traumatic brain injury. Maybe many, many years down the track, but definitely not early on."* (Health Professional)	

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Aerobic fitness training seems feasible in rehabilitation settings when delivered or supervised by health professionals. There are inconsistencies in the current delivery e.g., five of the six sites (83%) provided aerobic training, all delivered by physiotherapists, except for one site that also delivered aerobic training by exercise physiologists and/or allied health assistants in addition to physiotherapists. None of the paediatric sites conducted aerobic fitness tests to set training parameters. Three of the five sites providing aerobic training monitored intensity, either by observation or rating of perceived exertion. 4/6 (67%) of the sites refer to external providers for aerobic training, either to another physiotherapist or an exercise physiologist. The same amount of services train family/support workers to supervise aerobic training though the	• Health services may not have procedures and staff with knowledge and skills to conduct a fitness test. • Modified fitness testing protocols have been developed and tested in adult TBI (Hassett 2007) and paediatric TBI (Rossi 1996) and Cerebral Palsy (Verschuren 2006).

	frequency differed (2/4 frequently, 2/4 sometimes). Barriers to delivering aerobic training included resources (4/6); time (3/6); and not a priority (3/6). **BRIDGES qualitative research with stakeholder groups:** To deliver aerobic exercise in community settings may require specific resources (e.g., equipment, staff) and appropriate opportunities (e.g., inclusive or disability specific facilities and programs). Funding from state-based funders or NDIS may support this, however it would need to meet legislative requirements, fit within participant-developed goal and require submission of paperwork. *"The NDIS pays for the support worker to take her to the hydrotherapy. We pay for the pool cost, which, that's only $4 a time."* (Family member) *"the NDIS will fund modified recreational activities including equipment, but you need to clearly show that again it's reasonable and necessary and that what you're asking to do is not something like if you ask just to buy an e-bike, it has to be clearly linked to the fact that it's linked to your disability and what you're on the scheme for.* "(Service funder) Aerobic exercise opportunities are likely to arise in the school setting. There needs to be a willingness of schools to engage with outside providers (e.g., health professionals) and to see the importance of aerobic exercise participation as part of the education curriculum for children living with disabilities such as TBI. *"One of the facilitators can be the schooling environment. If you've got the right people in the schooling environment that can help promote physical activity in a way that is enjoyable, successful, meaningful, then that means their participation in those areas can be positively influenced, rather than them sitting out on things or timekeeping or keeping score, any of those terrible things."* (Health Professional)	

SUMMARY OF FINDINGS TABLE

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured aerobic exercise training	control	Relative (95% CI)	Absolute (95% CI)		
Cardiorespiratory fitness (motor-assisted elliptical training) (follow-up: range 55 days to 64 days; assessed with: Total exercise time, resting & exercise HR)												
1	observational studies	very serious	not serious	not serious	very serious[a]	none	Case 1: 8yr old. Session 1 exercise time 17mins. Average exercise HR: 116bpm, resting HR: 103bpm. Session 24 exercise time: 52mins. Average exercise HR: 123bpm, resting HR: 92bpm. Case 2: 7 yr old. Session 1 exercise time 20mins. Average exercise HR: 116bpm, resting HR: 101bpm. Session 24 exercise time: 61mins. Average exercise HR: 104bpm, resting HR: 82bpm. Case 3: 9 yr old. Session 1 exercise time 20mins. Average exercise HR: 104bpm, resting HR: 93bpm. Session 24 exercise time 60mins. Average exercise HR: 109bpm, resting HR: 76bpm.				⨁◯◯◯ Very low	CRITICAL
Comorbidities and mortality												
0									not estimable		-	CRITICAL
Walking capacity (follow-up: range 55 days to 64 days; assessed with: 2MWT)												
1	observational studies	very serious	not serious	not serious	very serious[a]	none	Case 1: 8yr old. Baseline=89.9m. End of intervention=91.4m. (1.5m increase) Case 2: 7 yr old. Baseline=124.1m. End of intervention=176.8m (43% increase) Case 3: 9 yr old. Baseline=170.4m. End of intervention=192m. (13% increase).				⨁◯◯◯ Very low	CRITICAL
Combined mobility (follow-up: range 55 days to 64 days; assessed with: Paediatric Balance Scale (range 0 to 56; higher better))												
1	observational studies	very serious	not serious	not serious	very serious[a]	none	Case 1: 8 yr old. Baseline 29. End of intervention 36. (24% increase) Case 2: 7 yr old. Baseline 37, End of intervention 40 (3 point increase) Case 3: 9 yr old. Baseline 55. End of intervention 56 (1 point increase)				⨁◯◯◯ Very low	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured aerobic exercise training	control	Relative (95% CI)	Absolute (95% CI)		
Physical activity												
0									not estimable		-	IMPORTANT
Body composition												
0									not estimable		-	IMPORTANT
Mood												
0									not estimable		-	IMPORTANT

CI: confidence interval

Explanations

a. Sample size 3.

RISK OF BIAS ASSESSMENT

Outcomes: cardiorespiratory fitness, walking capacity and combined mobility

Burnfield 2021:

- Risk of bias (ROBINS-I)

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
Burnfield 2021	-	+	+	+	?	-	+	-

Other important and critical outcomes not measured.

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Clinical question 3: Muscle strength training for adults and older adults with moderate to severe traumatic brain injury

Clinical question

Should structured **muscle strengthening** training compared to control be used for **adults and older adults** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home

Perspective: Health systems

Outcomes of interest:

1.	Muscle strength	CRITICAL
2.	Combined mobility	CRITICAL
3.	Walking capacity	IMPORTANT
4.	Balance	IMPORTANT
5.	Co-morbidities and mortality	IMPORTANT
6.	Body composition	IMPORTANT
7.	Physical activity	IMPORTANT

Strong recommendation:

For adults and older adults after moderate to severe traumatic brain injury, we recommend individually-tailored muscle strengthening exercise, including ballistic training, across the continuum of care.

Good Practice Points:

We suggest:

- Assessment of muscle strength is conducted prior to commencing strength training.
- For very weak muscles, strength training is set-up to make it as easy as possible to elicit muscle activity (e.g., reducing friction, reducing or removing gravity, working in

mid-range, electrical stimulation and/or electromyographic biofeedback, and supported weight bearing) and high repetitions are encouraged.

- Health professionals consider the muscle groups involved, and their function, when developing muscle strength training programs to improve mobility and other functional tasks.
- Health professionals consider specificity of training (i.e., power vs strength vs endurance) when prescribing mode of muscle strength training.
- Muscle strength training dosage is prescribed according to American College of Sports Medicine guidelines.
- Muscle strength training is transitioned from health settings to community-based physical activity settings where appropriate.

Justification

Overall justification

Mobility limitations are a common problem for adults and older adults after msTBI. Ballistic exercise training can improve mobility.

Detailed justification

Problem

Weakness is a common motor impairment after msTBI. Walking and mobility limitations are also common problems after a TBI with weakness contributing to these limitations. Progressive resistance strength training can reduce muscle weakness, but has little effect on activity-level outcomes, such as mobility.

Desirable Effects

The effect of ballistic resistance training compared to non-ballistic exercise on mobility is likely to range between no difference to a large clinically important difference, particularly in those with more severe physical disability.

Certainty of evidence

The single RCT that informs the evidence has a low risk of bias and provides moderate certainty evidence.

Balance of effects

Moderately strong effects of the intervention and trivial undesirable effects (i.e., incidence of SAEs and AEs).

Acceptability

Good acceptability from multiple stakeholders.

Feasibility

Feasible to deliver in inpatient and post-rehabilitation settings, although implementation support will be needed, especially for services and clinicians working with individuals with higher support needs.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large	Varies	Don't know	
UNDESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large	Varies	Don't know	
CERTAINTY OF EVIDENCE	Very low	Low	**Moderate**	High	No included studies		
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	**Favors the intervention**	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High	**No included studies**		
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	**Increased**	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
FEASIBILITY	No	Probably no	**Probably yes**	Yes	Varies	Don't know	

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

<table>
<tr><th colspan="3">Problem
Is the problem a priority?</th></tr>
<tr><th>JUDGEMENT</th><th>RESEARCH EVIDENCE</th><th>ADDITIONAL CONSIDERATIONS</th></tr>
<tr><td>○ No
○ Probably no
○ Probably yes
● Yes
○ Varies
○ Don't know</td><td>TBI evidence about reduced muscle strength:

Reduced lower limb muscle strength commonly affects adults with msTBI. Adults with TBI experience muscle weakness due to the upper motor neuron lesion causing a disruption to the motor neurons normally activating muscles. Muscle weakness is also due to disuse of muscles from prolonged inactivity, which causes the muscles to atrophy. Muscle weakness can be more significant in those with severe TBIs, due to hormonal disturbances from the brain injury and acute care management that causes hypercatabolism (Hassett et al., 2015).

There is good evidence that muscle strengthening exercises can improve muscle strength, though this has not necessarily translated to improved walking and mobility outcomes in neurological populations, including TBI (Williams et al., 2014).

A recent RCT demonstrated ballistic strength exercises intended to improve lower limb power generation capabilities during walking, improved mobility outcomes more than non-ballistic exercises (Williams et al., 2022).

TBI evidence about risk of morbidity and mortality:

A recent study from US-based TBI-models system investigated morbidity and mortality after TBI (Izzy et al., 2022). The study included 4351 patients with msTBI (median [IQR] age, 47 [30-58] years, 45% of participants were women). All comorbidities in the TBI subgroups emerged within a median (IQR) of 3.5 (1.8-6.0) years after injury. Individuals with msTBI, compared with unexposed patients, had higher risk of mortality (432 deaths [9.9%] vs 250 deaths [5.7%]; P < .001); postinjury hypertension (Hazard Ratio, 1.3; 95%CI, 1.1-1.7), coronary artery disease (Hazard Ratio, 2.2; 95%CI, 1.6-3.0), and adrenal insufficiency (Hazard Ratio, 6.2; 95%CI, 2.8-13.0) were also associated with higher mortality.

General population evidence about reduced muscle strength and risk of morbidity and mortality:

Data from the general population shows higher levels of upper limb strength is associated with a reduced risk of all-cause mortality (HR=0.69; 95% CI, 0.64-0.74) compared with lower muscular strength. Adults with higher levels of leg strength have a 14% lower risk of death</td><td>Progressive resistance training has been shown to improve muscle strength in neurological population, such as stroke and TBI, but these improvements do not carry over into improvements at the activity level (i.e., mobility) (Dorsch et al., 2018; Williams et al., 2014). This is primarily because strength training interventions have not targeted the main muscle groups that provide the majority of power generation for forward propulsion (i.e., ankle plantarflexors, hip flexors and hip extensors), and exercises performed in the training are done so at low speed with little power production (Williams et al., 2014).

To improve walking and other high level mobility tasks, muscle groups involved in these tasks need to be able to contract with strength and speed. Ballistic exercise training, or fast resistance exercise, can improve muscle power generation and has shown to be safe and feasible in neurological populations (Cordner et al., 2021).</td></tr>
</table>

	(HR=0.86: 95% CI, 0.80-0.93; P<.001) compared with adults with lower leg strength (Garcia-Hermoso et al., 2018). Data from a prospective analysis of low muscle mass and low muscle strength association with all-cause mortality in the National Health and Nutrition Examination Survey population (4,449 participants, >50 years and older), all-cause mortality was significantly higher among individuals with low muscle strength (Li et al., 2018).	

Desirable Effects

How substantial are the desirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	**Evidence from TBI:** See summary of findings table below. Replacing three sessions per week of non-ballistic exercise rehabilitation with ballistic resistance training resulted in similar or better mobility (as measured by the HiMAT (0 to 54); MD=3; 95%CI 0 to 6; moderate certainty evidence) that was largely maintained at 6 months (MD=3; 95%CI -1 to 6; moderate certainty evidence). Ballistic resistance training and non-ballistic exercise had similar effects on the secondary outcome measures (muscle strength, walking speed, balance). An exploratory subgroup analysis found the use of ballistic resistance training led to even greater improvements in mobility among those with more severe disability (baseline HiMAT score <27; MD=6; 95%CI 1 to 10). The clinically worthwhile difference in HiMAT is ≥4, therefore the effect of ballistic resistance training compared to non-ballistic exercise on mobility is likely to range between no difference to a large clinically important difference, particularly in those with more severe physical disability. **Evidence from Australian and New Zealand Living Clinical Guidelines for Stroke Management** • For stroke survivors with reduced strength in their arms or legs, progressive resistance training should be provided to improve strength. (Dorsch et al. 2018). *Strong recommendation, moderate quality evidence.* (Saunders et al., 2020, Cochrane review).	American College of Sports Medicine (ACSM) guidelines for muscle strength training (American College of Sports Medicine, 2009): • *Frequency:* 2-3x week. • *Intensity:* 60-70% 1-Repetition maximum (RM) (for novice to intermediate exercises) or ≥80% 1-RM (experienced exercises), 8–15 repetitions, 1 - 4 sets (for muscular strength) or 15–20 repetitions, ≥2 sets (for muscular endurance). • *Type:* Target major muscle groups. • Ballistic exercise training, a specific mode of resistance training, aims to increase the rate of force production (i.e., power generation) by muscles groups. Initial loads start low to facilitate high contraction velocities. When the individual could consistently perform the high velocity exercises, the load can be progressively increased. Examples of ballistic resistance training used in Williams et al. (2022) to improve mobility: leg extension jumps on a 'leg sled'; calf raises on a 'leg sled'; stair ascent and descent; reciprocal leg extension on a mini-trampoline; and fast cyclical hip and knee flexion in standing. • A circuit class, where patients rotate around a circuit of exercise stations, including lower limb functional strengthening exercises may induce both

	• Muscle strength (composite measure): SMD (95%CI): 0.58 (0.06 to 1.1) higher, low certainty evidence. • Walking capacity (6-Minute Walk Test) MD (95%CI): 24.98 (11.98 to 37.98) m further, low certainty evidence. • Combined mobility (Berg Balance Scale) MD (95%CI): 3.27 (2.15 to 4.38) points, low certainty evidence. • Death: Risk difference 0.00 (-0.02 to 0.02), low certainty evidence. **Evidence from WHO physical activity guidelines for disability (Carty et al., 2021):** In stroke: evidence for improved walking speed, ability, and endurance, cardiorespiratory fitness, sensory motor function of the lower limb, balance, mobility, and activities of daily living.	cardiorespiratory and strength gains for people with severe TBI (Hassett et al., 2012).

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Evidence from TBI:** No significant negative effects were found on any of the critical or important outcomes. Only two study-related adverse events (AEs) in the intervention group were reported in the Williams et al. (2022) RCT. Both AEs were non-injurious falls that did not prevent the participant from continuing their exercise session or preclude them from continuing their involvement in the study. No serious adverse events (SAEs) were reported. **Evidence from stroke:** In a Cochrane review investigating the effects of physical fitness training in stroke, out of 20 studies of muscle strength training (803 participants), only one study reported deaths (n = 2, one in each study arm) as a reason for participant losses (Saunders et al., 2020). Overall, there was no statistically significant effect (RD 0.00, 95% CI −0.02 to 0.02; I2 = 0%; low certainty evidence). At end of follow-up, one out of five studies of muscle strength training reported four deaths (n = 4, two in each study arm) as the reason for participant losses. Overall, there was no statistically significant effect (RD 0.00, 95% CI −0.04 to 0.04; I2 = 0%; 251 participants; low certainty evidence). Similar to TBI data, not all studies explicitly measured AEs. Of those that did, AEs included cardiovascular events and falls, reported in both intervention and control groups.	**Clinical expertise input:** Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken.

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ● Moderate ○ High ○ No included studies	**Evidence from TBI:** See summary of findings table below. All outcomes rated as moderate certainty evidence. **Evidence from stroke:** (Saunders et al., 2020 Cochrane review): • Muscle strength (composite measure): SMD (95%CI): 0.58 (0.06 to 1.1) higher, low certainty evidence. • Walking capacity (6-Minute Walk Test) MD (95%CI): 24.98 (11.98 to 37.98) m further, low certainty evidence. • Combined mobility (Berg Balance Scale) MD (95%CI): 3.27 (2.15 to 4.38) points, low certainty evidence. • Death: Risk difference 0.00 (-0.02 to 0.02), low certainty evidence. **Evidence from WHO physical activity guidelines for disability (Carty et al., 2021):** Adults living with disability should also do muscle-strengthening activities at moderate or greater intensity that involve all major muscle groups on two or more days a week, as these provide additional health benefits. *Strong recommendation, moderate certainty evidence*	Nil.

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted in TBI to inform the value adults with msTBI place on the main outcomes. **BRIDGES qualitative research with people living with TBI:**	Nil.

	As a common symptom of TBI, fatigue was described as a potential barrier to physical activity by nearly all TBI participants in our qualitative study, even though they recognised the paradox of improving their overall fatigue through tiring physical activity: *"I was lying in a hospital bed for six weeks … then there was muscle wastage for the next 18 months as I tried to recover. So, I didn't have any strength to do anything, which meant I was always fatigued. I feel if you can improve people's strength and fitness, then they can cope with everyday tasks better. That gives them more energy. Therefore, they're less fatigued…. people don't seem to understand that to alleviate that fatigue, you have to work hard, which makes you more fatigued, but in the long run, you become less fatigued. That's the perception I'd like to change."* (P3)	

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ● Favors the intervention ○ Varies ○ Don't know	See summary of findings table below. Trivial undesirable effects and moderate desirable effects of moderate certainty. On the balance of desirable and undesirable effects, participating in muscle strength training, in particular ballistic exercises, is probably favoured over the alternative (i.e., not participating in muscle strength training).	Nil.

Resources required

How large are the resource requirements (costs)?"

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	Cost data is not available from any studies in TBI. The cost of the required resources likely varies depending on the needs of the person with TBI, e.g., if they can independently participate in muscle strength training, or if they need one-on-one supervision or specific equipment to facilitate strength training. A more resource intensive intervention (community fitness-centre based program including 3-month gym membership + 3 sessions/wk supervised by personal trainer) compared to a low resource intervention (unsupervised home-based program prescribed while in hospital) delivered better adherence and dosage of training. Patient-level outcomes were not different between groups (Hassett et al., 2009). **BRIDGES audit of brain injury services:** BRIDGES audit study for adult and older adult brain injury rehabilitation services across Australia (n = 21): Percentage of sites who have the following equipment for lower extremity strength training in inpatient and/or outpatient services: Hand held weights (21/21; 100%), Bands (19/21; 90%), cuff weights (18/21; 86%), weight machines (14/21; 67%), tilt table (13/21; 62%), jump trainer (9/21; 43%), suspension slings/springs (9/21; 43%), and weighted vests (4/21; 19%). **BRIDGES qualitative research with people living with TBI:** This work provided insights into costs for muscle strength training in the community: Costs of physical activities, transport and equipment and, primarily, variability in insurance coverage, played a very significant role in enabling or obstructing access to different types of physical activity including aerobic training: "*I get help by the NDIS, so that is a major factor in what exercise I choose to do…. I wouldn't have an exercise physiologist … coming to my house if we weren't getting help. I can guarantee, that's a big deal…. we couldn't afford to be supporting exercise physiology and the gym and all the other stuff if we weren't getting help.*" (P3) Whereas for others, especially those with higher support needs, it was essential to find an activity, often with a facilitator, that was more attuned to their needs: "*I need a personal trainer because my body is stronger than my brain. So if I didn't have the safety requirements of the personal trainer guide me through- yesterday with the leg press machine I did a hundred reps of 250 kilos and I couldn't do that on my own, because first I couldn't load up the machine with five 20 kilo plate from each side.*" (P20) **BRIDGES qualitative research with stakeholder groups:**	Nil.

	It was noted from multiple stakeholders the need for attendant care workers to support participation in physical activity (including muscle strength training) including supporting travel, motivation to do the activity, supervision of home or gym programs. *"Well, fortunately, most activities we do, we've had a physiotherapist come out and guide us, so we can do exercises that she can do. Obviously, she's restricted in doing exercises in a normal gym, because they don't cater for that properly."* (Family member) It was noted from health professional and community physical activity providers, that specialised/adapted equipment is needed for those with higher support needs that either needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment. "*... we've got some access to modified gyms, but trying to find gym access, plenty of people just trip over the weights and equipment. If they want to go back into a standard gym, that can be really difficult. And I think that cognition and behaviour, as well as their physical capacity of the actual clients, can become a great barrier. I think cost, we've touched on cost primarily because they often need supervision or assistance or care to be able to participate in something."* (Health Professional)	

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies include cost data about the resources required.	Nil.

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Nil.

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ● Increased ○ Varies ○ Don't know	• General population studies have shown lower physical activity levels (likely to include reduced levels of muscle strength) in lower socioeconomic areas. Providing an intervention to increase muscle strength will likely benefit those in more disadvantaged groups. • Access to inpatient rehabilitation services is within public health system, so access for all is dependent on need, not funding. • There is likely access to state-based funding and NDIS for any with moderate to severe injury (if meet inclusion criteria) to support muscle strength training post inpatient rehabilitation, but completion of forms etc for access to these funding schemes may be more challenging for those with lower socioeconomic backgrounds or less family support. • National guidelines may support providers to deliver and funders to fund muscle strength training for those living in more regional, rural and remote areas that aren't as linked in with specialist brain injury services.	Nil.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies	**Evidence from TBI studies:** In the Williams et al. (2022) RCT, by the end of the intervention, 13 participants (9%) were lost to follow-up and at 3-months post-intervention, 30 participants (21%; intervention group n = 14; control group n = 16) were lost to follow-up. The reasons for loss to follow-up were:	Nil.

○ Don't know	unavailability due to returning to a regional area (n = 16), COVID restrictions (n = 7) and withdrawal or refusal (n = 7). Adherence to the strength training intervention delivered in the Williams et al. (2022) RCT was good. The mean number of sessions delivered was 31 out of a possible 36 (86%), and this was similar between the intervention (mean 30 sessions) and control (mean 32 sessions) groups. Participants in the intervention group spent an average of 41 minutes exercising per 60-minute session (total time 2,878 minutes), compared with 45 minutes for the control group (total time 3,252 minutes). **BRIDGES audit of brain injury services:** Twenty-one adult services audited across Australia, of which seven admitted only working age adults and the remaining 14 admitted both working age adults as well as older adults. • *Location:* 8/8 states and territories; 17 major cities, two regional and two outer regional or remote. • *Type:* 14 public, three private, and four mixed; eight specialist brain injury services with inpatient service, six private practices that work with TBI clients, three inpatient rehabilitation services that manage some brain injury clients, two outpatient community rehabilitation teams, one specialist brain injury services transition/case management, and one acute neurosurgical ward. • 100% of the working adults' services reported delivering lower extremity strength training, including 20/21 (95%) for very weak muscles (Manual Muscle Test (MMT) 0 to 2/5) and 21/21 (100%) for weak muscles (MMT 3 to 4/5). • *Who:* In these services lower extremity strength training is delivered by physiotherapists (21/21; 100%), exercise physiologists (8/21; 38%), allied health assistants (3/21; 14%), and OTs (1/21; 5%). **BRIDGES qualitative research with people living with TBI:** The challenge of being active while managing TBI symptoms required significant adaptability which was greatest for those with the most profound injuries. The limitations they were working around involved physical and cognitive capabilities, with flow on effects such as the need for support workers or help with travel to physical activity venues: *"I can't go to the gym by myself, because I don't remember what I'm supposed to do with the machines and how I actually do it, so I have to have somebody come with me…. I can't just go walk my dog on my own, because I could fall over. So everything that I do physically now has to have somebody there with me. So I can't even just go for a walk around the block without having somebody there to make sure that I'm okay. So it's a little bit harder…. I can't drive. So anything that I go and do, I have to have somebody to take me there and it's limiting. Public*	

	transport where I live is there, but it's hard to get to. So again, I've got to have somebody drive me to get there. So the sort of independence that other people have, I don't have.... If I could get to places ... under my own steam, I would be really excited and would go and do things more often. But I just can't. So I have to understand my limitations and be okay with those to then try and see what else I can go and do." (P2) **BRIDGES qualitative research with stakeholder groups:** In relation to acceptability of the WHO guideline level of physical activity (150-300min moderate to vigorous physical activity; strength training exercise two days per week), all stakeholder groups were overall accepting of this but identified that some with more severe injuries (cognitive, behavioural and/or physical impairments) may not be able to meet this level (intensity and/or duration) or may need additional support/equipment to achieve this. It was suggested resources that provide examples of how a range of different adults after msTBI meet these levels (and how to define moderate intensity activity) would be useful. It was also noted that the good practice points of the WHO guideline were very important. Stakeholders noted the benefits and importance of muscle strengthening exercise to adults after msTBI: *"Give them hope that there is something they can do that actually will work. Then if you get them on a really good weights programme where people actually know what they're doing and not messing around, which is what I see so often, get people to do this properly, then people will get amazing results and you'll change people's lives forever."* (Exercise provider) *"I'm reluctant to give up the one-on-one session, because that's just focusing on his muscle strength and all of that, which is really good."* (Family member)	
Feasibility Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Lower extremity strength training seems feasible in rehabilitation settings when delivered or supervised by health professionals, for both weak and very weak muscles. Most services (20/21; 95%) assessed muscle strength to set training parameters, with the majority using manual muscle testing (MMT) to achieve this. There is variability in the equipment used for strength training and dosage provided. For example, for individuals with very weak muscles (MMT 1-2), use of reducing friction, using electrical stimulation or EMG biofeedback, manual guidance or hydrotherapy is used for between 0% to 100% of eligible patients across the	Nil.

	services. For increasing strength in weak muscles (MMT 3-4), progressive resistance training is used by services for between 20-100% eligible patients, ballistic strength training 10-100% eligible patients, and general strength training 30-100% eligible patients. More than half (13/21; 62%) of the services refer clients to an external provider (i.e., physiotherapist, exercise physiologist, personal trainer, or community gym) for strength training. All of the services that delivered strength training to people with msTBI trained family/support workers to supervise their family members/clients' strength training program. A number of barriers were identified by the services to delivering lower extremity strength training, including a lack of resources (10/21; 48%) and time (7/21; 33%), and safety concerns (5/21; 24%). **Evidence from stroke rehabilitation:** Implementation issues have been raised in stroke rehabilitation. A qualitative study was conducted in Australia to explore the perceived barriers and facilitators that influence Australian physiotherapy practices when prescribing strength training with people with stroke undergoing gait rehabilitation. They found patient factors, such as ensuring patient enjoyment and engagement, influenced the approach to strength training, as did the workplace context within which the strength training was delivered. They also found the participating physiotherapists displayed wide variation in their knowledge, interpretation and implementation of strength training principles and strength training exercise prescription was seldom evidence or guideline based (Tole et al., 2022). **BRIDGES qualitative research with people living with TBI:** Moving from a highly structured, well-supported program of rehabilitation into self-directed physical activity was a considerable challenge impacted by lack of guidance about, and availability of, suitable options: *"… it was very apparent to me that I had to do more than what I was doing through my basic rehab….. I was very lucky. I was able to draw on knowledge that I had pre-accident. I've done a lot of internet searching, spoke to a lot of people, physios, but I'll be perfectly honest with you, I found very little out there to actually help.… as soon as you came out of the hospital there was outpatient stuff, but once you'd left that it was like, "Well, yeah, go to the gym, try and get fitter and healthier." But … there was no support. There was nothing there…. I wanted to make my own way. I didn't want somebody holding my hand whilst I was doing things, but equally, I wanted to feel secure in the environment that I was at…. It's a shame there isn't anything that helps us in that space between leaving hospital and obviously recovering."* (P3) And some found the impacts of brain injury on executive function undermined their efforts to be active, despite their commitment and intentions:	

	"...obviously you can go to the gym and do that stuff, but again, because of my injury, I have problems with initiating. So I know it's like my start button is broken, so I know that I can do things or I know that I need to do something. I can't make myself do it." (P2) **BRIDGES qualitative research with stakeholder groups:** To deliver muscle strengthening exercise in community settings may require specific resources (e.g., equipment, staff) and appropriate opportunities (e.g., inclusive or disability specific facilities and programs). Funding from state-based funders or NDIS may support this, however it would need to meet legislative requirements, fit within participant-developed goal and require submission of paperwork. Several stakeholders wanted examples of how to support their clients to exercise at a sufficient intensity, particularly the more severe TBI patients: *"... maybe if you could write some case studies or give some examples. ......And I guess if you could pick out different people, then you'd have different experiences or something like that. So just so that people could actually see whatever their experiences they could see different ways of doing it."* (Individual with TBI) *"I think examples would definitely be ... so people understand that more and what sort of level of exercise, what sort of activities go with each of those."* (Family member of person with TBI) *".. I would like to see is probably some suggestions or recommendations for extremely severe TBI. For example, I have a couple who are in sort of a persistent vegetative state and there's no real clear guidance on what's going to be appropriate."* (Service funder) Other stakeholders spoke of the challenge for adults after msTBI to access standard, community gyms to undertake their strength training. *"Well, fortunately, most activities we do, we've had a physiotherapist come out and guide us, so we can do exercises that she can do. Obviously, she's restricted in doing exercises in a normal gym, because they don't cater for that properly. "*(Family member) *"... we've got some access to modified gyms, but trying to find gym access, plenty of people just trip over the weights and equipment. If they want to go back into a standard gym, that can be really difficult. And I think that cognition and behaviour, as well as their physical capacity of the actual clients, can become a great barrier. I think cost, we've touched on cost primarily because they often need supervision or assistance or care to be able to participate in something."* (Health Professional)	

SUMMARY OF FINDINGS TABLE

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured muscle strengthening	control	Relative (95% CI)	Absolute (95% CI)		
Muscle strength at end of 3-month intervention (ballistic strength training vs. non-ballistic exercises) (follow-up: mean 3 months; assessed with: Six-repetition maximum seated single leg press (kg). Higher = better)												
1	randomised trials	not serious[a]	not serious	not serious[b]	serious[c]	none	60	68	-	MD **3 kg lower** (10.2 lower to 4.2 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Muscle strength at end of follow-up (ballistic strength training vs. non-ballistic exercises) (follow-up: mean 6 months; assessed with: Six-repetition maximum seated single leg press (kg). Higher = better)												
1	randomised trials	not serious[a]	not serious	not serious[b]	serious[c]	none	51	58	-	MD **1 kg higher** (7.8 lower to 9.8 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Combined mobility at end of 3-month intervention (ballistic strength training vs. non-ballistic exercises) (follow-up: mean 3 months; assessed with: HiMAT - higher score = better; Scale from: 0 to 54)												
1	randomised trials	not serious[a]	not serious	not serious[b]	serious[d]	none	62	69	-	MD **3 higher** (0.09 lower to 6.09 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Combined mobility at end of follow-up (ballistic strength training vs. non-ballistic exercises) (follow-up: mean 6 months; assessed with: HiMAT - higher score = better; Scale from: 0 to 54)												
1	randomised trials	not serious[a]	not serious	not serious[b]	serious[d]	none	56	58	-	MD **3 higher** (0.86 lower to 6.86 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Walking speed at end of 3-month intervention (ballistic strength training vs. non-ballistic exercises) (follow-up: mean 3 months; assessed with: 10-metre walk test (m/s). Faster = better)												
1	randomised trials	not serious[a]	not serious	not serious[b]	serious[c]	none	62	69	-	MD **0.01 m/s lower** (0.12 lower to 0.1 higher)	⨁⨁⨁◯ Moderate	IMPORTANT
Walking speed at end of follow-up (ballistic strength training vs. non-ballistic exercises) (follow-up: mean 6 months; assessed with: 10-metre walk test (m/s). Faster = better)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured muscle strengthening	control	Relative (95% CI)	Absolute (95% CI)		
1	randomised trials	not serious[a]	not serious	not serious[b]	serious[c]	none	56	58	-	MD **0.01 m/s lower** (0.14 lower to 0.12 higher)	⨁⨁⨁◯ Moderate	IMPORTANT
Balance at end of 3-month intervention (ballistic strength exercises vs. non-ballistic exercises) (follow-up: mean 3 months; assessed with: Single Leg Stance time (s). More = better; Scale from: 0 to 30)												
1	randomised trials	not serious[a]	not serious	not serious[b]	serious[e]	none	62	69	-	MD **2 s fewer** (3.67 fewer to 0.33 fewer)	⨁⨁⨁◯ Moderate	IMPORTANT
Balance at end of follow-up (ballistic strength exercises vs. non-ballistic exercises) (follow-up: mean 6 months; assessed with: Single Leg Stance time (s). More = better; Scale from: 0 to 30)												
1	randomised trials	not serious[a]	not serious	not serious[b]	serious[c]	none	56	58	-	MD **1.2 s fewer** (3.25 fewer to 0.85 more)	⨁⨁⨁◯ Moderate	IMPORTANT
Comorbidities and mortality - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	IMPORTANT
Body composition - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	IMPORTANT
Physical activity - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	IMPORTANT

CI: confidence interval; **MD:** mean difference

EXPLANATIONS

a. Not downgraded due to low risk of bias for all domains as assessed by ROB-2.

b. Study population TBI severity (Glasgow Coma Scale mean = 6, standard deviation = 4) suggestive of msTBI.

c. Downgraded one level to do wide confidence intervals and unclear if study powered for outcome.

d. Downgraded one level due to wide confidence intervals.

e. Downgraded one level over concerns study not powered to detect change in outcome.

FOREST PLOTS AND RISK OF BIAS ASSESSMENT

Outcome: Muscle strength

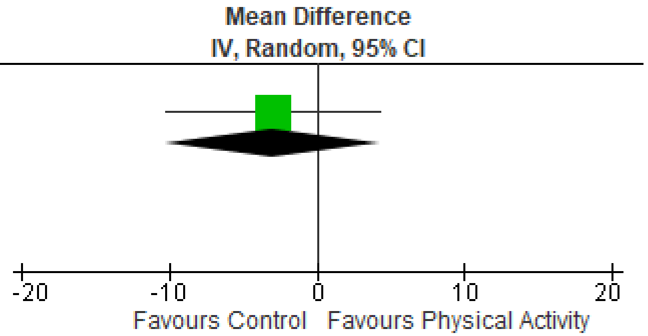
Muscle strength at end of intervention: (muscle strengthening vs. non-ballistic exercises)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot: 6-Repetition maximum leg press

	Experimental			Control				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
6.1.1 6RM leg press (kg)								
Williams 2022	19	18	62	22	24	69	100.0%	-3.00 [-10.22, 4.22]
Subtotal (95% CI)			**62**			**69**	**100.0%**	**-3.00 [-10.22, 4.22]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.81 (P = 0.42)								



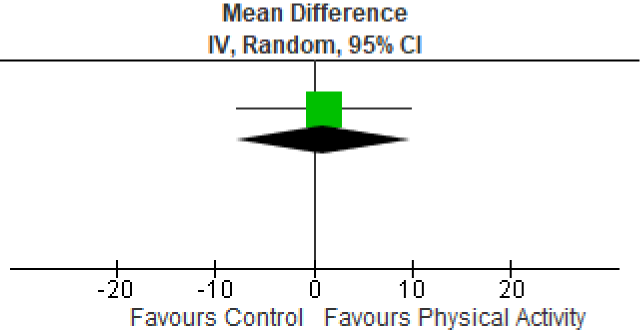
Muscle strength at end of follow-up: (muscle strengthening vs. non-ballistic exercises)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.2.1 6RM leg press (kg)								
Williams 2022	25	24	56	24	24	58	100.0%	1.00 [-7.81, 9.81]
Subtotal (95% CI)			**56**			**58**	**100.0%**	**1.00 [-7.81, 9.81]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.22 (P = 0.82)								



Outcome: Combined mobility

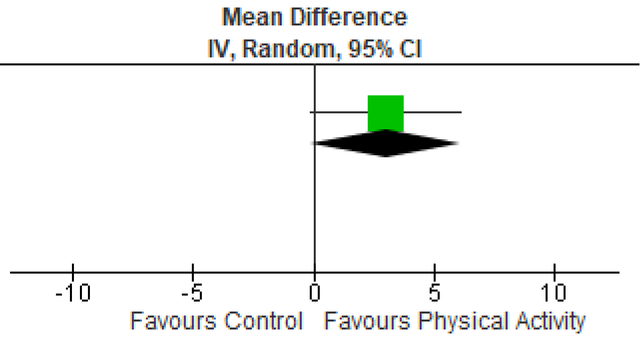
Combined mobility at end of intervention: (muscle strengthening vs. non-ballistic exercises)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot: HiMAT (0 to 54 points)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.3.1 HiMAT								
Williams 2022	11	9	62	8	9	69	100.0%	3.00 [-0.09, 6.09]
Subtotal (95% CI)			**62**			**69**	**100.0%**	**3.00 [-0.09, 6.09]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.90 (P = 0.06)								



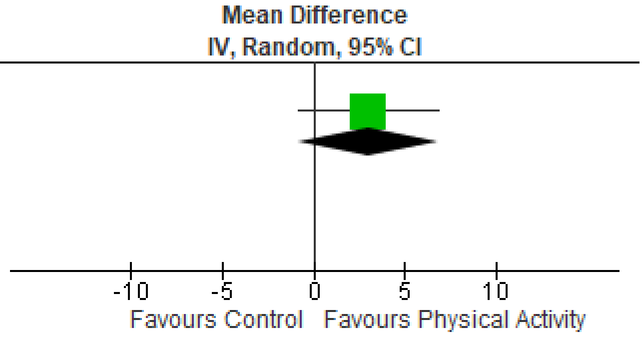
Combined mobility at end of follow-up: (muscle strengthening vs. non-ballistic exercises)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.4.1 HiMAT								
Williams 2022	14	11	56	11	10	58	100.0%	3.00 [-0.86, 6.86]
Subtotal (95% CI)			**56**			**58**	**100.0%**	**3.00 [-0.86, 6.86]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.52 (P = 0.13)								



Outcome: Walking capacity

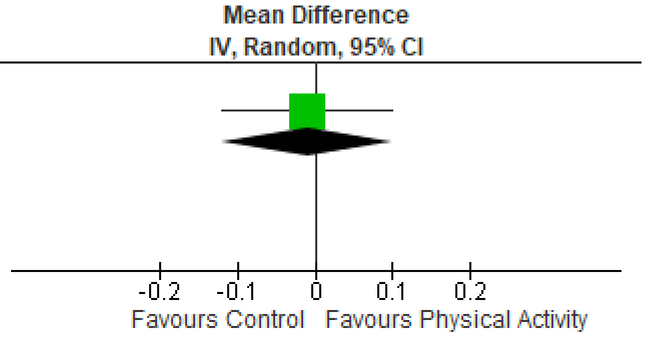
Walking capacity at end of intervention: (muscle strengthening vs. non-ballistic exercises)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.5.1 10-m walk test (m/s)								
Williams 2022	0.27	0.34	62	0.28	0.29	69	100.0%	-0.01 [-0.12, 0.10]
Subtotal (95% CI)			**62**			**69**	**100.0%**	**-0.01 [-0.12, 0.10]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.18 (P = 0.86)								



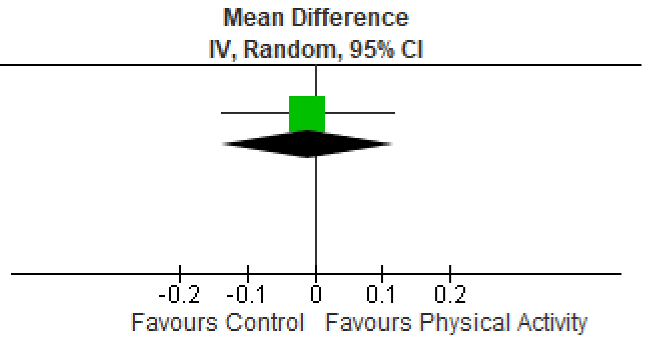
Walking capacity at end of follow-up: (muscle strengthening vs. non-ballistic exercises)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.6.1 10-m walk test (m/s)								
Williams 2022	0.34	0.36	56	0.35	0.33	58	100.0%	-0.01 [-0.14, 0.12]
Subtotal (95% CI)			**56**			**58**	**100.0%**	**-0.01 [-0.14, 0.12]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.15 (P = 0.88)								



Outcome: Balance

Balance at end of intervention: (muscle strengthening vs. non-ballistic exercises)

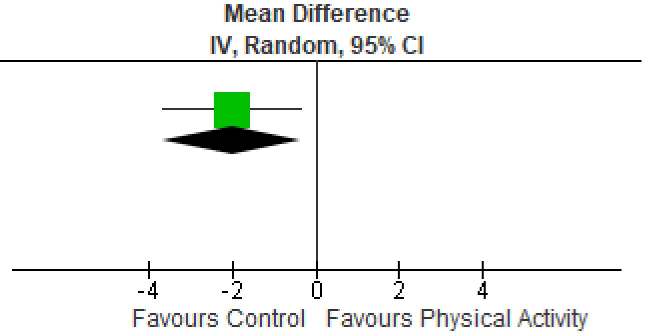
- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot: Single-leg stance time (0 to 30-seconds)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.7.1 SLS time (s)								
Williams 2022	3	4.2	62	5	5.5	69	100.0%	-2.00 [-3.67, -0.33]
Subtotal (95% CI)			**62**			**69**	**100.0%**	**-2.00 [-3.67, -0.33]**

Heterogeneity: Not applicable
Test for overall effect: Z = 2.35 (P = 0.02)



Balance at end of follow-up: (muscle strengthening vs. non-ballistic exercises)

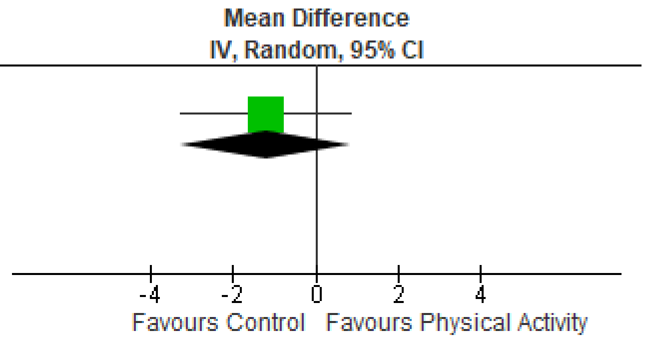
- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias):	Blinding of outcome assessment (detection bias):	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias

				Objective outcomes	Subjective outcomes			
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.8.1 SLS time (s)								
Williams 2022	3.8	4.8	56	5	6.3	58	100.0%	-1.20 [-3.25, 0.85]
Subtotal (95% CI)			**56**			**58**	**100.0%**	**-1.20 [-3.25, 0.85]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.15 (P = 0.25)								



Outcome: Morbidity and Mortality

- No studies have measured this outcome.

Outcome: Body composition

- No studies have measured this outcome.

Outcome: Physical activity

- No studies have measured this outcome.

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Clinical question 4: Muscle strength training for children and adolescents with moderate to severe traumatic brain injury

Clinical question

Should structured **muscle strengthening** training compared to control be used for **children and adolescents** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home
- Schools

Perspective: Health systems

Outcomes of interest:

1.	Muscle strength	CRITICAL
2.	Combined mobility	CRITICAL
3.	Walking capacity	IMPORTANT
4.	Balance	IMPORTANT
5.	Co-morbidities and mortality	IMPORTANT
6.	Body composition	IMPORTANT
7.	Physical activity	IMPORTANT

Conditional recommendation:

For children and adolescents after moderate to severe traumatic brain injury we suggest regular muscle strengthening play and/or exercise that is individually-tailored and across the continuum of care.

Good Practice Points:

We suggest:

- Muscle strength training aims to achieve goals established collaboratively where the child's voice is at the centre.
- Assessment of muscle strength is conducted for school aged children prior to commencing strength training.

- For very weak muscles, strength training is set-up to make it as easy as possible to elicit muscle activity (e.g., reducing friction, reducing or removing gravity, working in mid-range, electrical stimulation and/or electromyographic biofeedback, and supported weight bearing) and high repetitions are encouraged.
- Muscle strength training dosage is prescribed according to American College of Sports Medicine guidelines.
- Health professionals consider the muscle groups involved, and their function, when developing muscle strength training programs to improve mobility and other functional tasks.
- Health professionals consider specificity of training (i.e., power vs strength vs endurance) when prescribing mode of muscle strength training.
- Muscle strength training is transitioned from health settings to community-based physical activity settings where appropriate.

Justification

Overall justification

Muscle strength is impaired after msTBI. The World Health Organisation (WHO) recommend muscle strength training for children and adolescents living with a disability.

Detailed justification

Problem

Muscle weakness is a common impairment after msTBI which is causing limitations in activities such as standing up and walking and will restrict participation in meaningful activities such as sport and play.

Desirable Effects

The WHO strongly recommend muscle and bone strengthening activities for children and adolescents living with a disability.

Undesirable Effects

There are few examples of adverse events or serious adverse events as a result of muscle strength training for adults or older adults after msTBI. The WHO suggest there are no major risks engaging in physical activity, including muscle strength training, for children and adolescents living with a disability.

Acceptability

Good acceptability from multiple stakeholders.

Feasibility

Feasible to deliver in inpatient and post-rehabilitation settings, although implementation support will be needed, especially for services and clinicians working with children and adolescents with higher support needs.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
DESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large	Varies	Don't know	
UNDESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large	Varies	Don't know	
CERTAINTY OF EVIDENCE	Very low	Low	Moderate	High	No included studies		
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High	No included studies		
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	No included studies
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
FEASIBILITY	No	Probably no	**Probably yes**	Yes	Varies	Don't know	

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

<table>
<tr><th colspan="3">PROBLEM
Is the problem a priority?</th></tr>
<tr><td>JUDGEMENT</td><td>RESEARCH EVIDENCE</td><td>ADDITIONAL CONSIDERATIONS</td></tr>
<tr><td>○ No
○ Probably no
○ Probably yes
● Yes
○ Varies
○ Don't know</td><td>Children and adolescents experience reduced lower limb muscle strength following TBI (Drijkoningen et al., 2015; Katz-Leurer et al., 2010; Katz-Leurer et al., 2009). Deficits in lower limb muscle strength after TBI can impact the walking ability, balance and co-ordination of children and adolescents. In a small group (n = 19) of children and adolescents after msTBI, asymmetry in muscle strength was predictive of a poorer balance control and a more variable and asymmetric gait (Drijkoningen et al., 2015). This has negative implications for a child's or adolescent's engagement in physical activity (Katz-Leurer et al., 2010), which can impact an individual's physical and psychosocial wellbeing (Sallis et al., 2000).</td><td>Nil.</td></tr>
<tr><th colspan="3">DESIRABLE EFFECTS
How substantial are the desirable anticipated effects?</th></tr>
<tr><td>JUDGEMENT</td><td>RESEARCH EVIDENCE</td><td>ADDITIONAL CONSIDERATIONS</td></tr>
<tr><td>○ Trivial
● Small
○ Moderate
○ Large
○ Varies
○ Don't know</td><td>There is no evidence to guide this judgement in children and adolescents in TBI research.

Evidence in adults with TBI:

Ballistic exercise training had a moderate effect on mobility in adults after msTBI but was no better (or worse) than non-ballistic exercises on measures of balance, walking ability, or muscle strength (Williams et al., 2022; moderate certainty evidence).

Evidence from WHO physical activity guidelines for disability (Carty et al., 2021):

• WHO guideline development group considered the evidence for children without disability could be extrapolated for children living with disability for key outcomes including favourable outcomes on cardiorespiratory and muscular fitness, cardiometabolic health, bone health, cognitive outcomes, mental health, and adiposity.
• WHO guideline development group considered evidence for physical activity for children living with intellectual disability and children with attention deficit hyperactivity disorder (ADHD). They found low-certainty evidence of improved physical function in children with intellectual disability and moderate-certainty evidence that moderate to vigorous physical activity can have beneficial effects on</td><td>Nil.</td></tr>
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- cognition, including attention, executive function, and social disorders in children with ADHD.

The WHO guidelines recommend for children and adolescents (aged 5–17) living with disability it is recommended that:

- Vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone should be incorporated at least 3 days a week. *Strong recommendation, moderate certainty evidence*

</td><td></td></tr>
<tr><td colspan="3">

UNDESIRABLE EFFECTS
How substantial are the undesirable anticipated effects?

</td></tr>
<tr><td>JUDGEMENT</td><td>RESEARCH EVIDENCE</td><td>ADDITIONAL CONSIDERATIONS</td></tr>
<tr><td>

● Trivial
○ Small
○ Moderate
○ Large
○ Varies
○ Don't know

</td><td>

There is no evidence to guide this judgement in children and adolescents in TBI research.

Evidence from adults with TBI:

No significant negative effects were found on any of the critical or important outcomes. Only two study-related adverse events (AEs) in the intervention group were reported. Both AEs were non-injurious falls that did not prevent the participant from continuing their exercise session or preclude them from continuing their involvement in the study. No serious adverse events (SAEs) were reported.

Evidence from WHO physical activity guidelines for disability (Carty et al., 2021):

The WHO guidelines suggest the following Good Practice Point for children and adolescents (aged 5–17) living with disability:

- There are no major risks for children and adolescents living with disability engaging in physical activity when it is appropriate to an individual's current activity level, health status and physical function; and the health benefits accrued outweigh the risks.

</td><td>

Clinical expertise input:

Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken.

Cochrane review on exercise interventions in cerebral palsy (Ryan et al., 2017):

Thirteen trials did not report adverse events, seven reported no AEs, and nine reported non-serious AEs.

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CERTAINTY OF EVIDENCE
What is the overall certainty of the evidence of effects?

</td></tr>
<tr><td>JUDGEMENT</td><td>RESEARCH EVIDENCE</td><td>ADDITIONAL CONSIDERATIONS</td></tr>
</table>

○ Very low ○ Low ○ Moderate ○ High ● No included studies	There is no evidence to guide this judgement in children and adolescents in TBI research. **Evidence from adults with TBI:** All outcomes evaluated were rated as moderate certainty evidence.	Nil.
VALUES Is there important uncertainty about or variability in how much people value the main outcomes?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted in TBI to inform the value children and adolescents after msTBI place on the main outcomes. **BRIDGES qualitative research with people living with TBI:** As a common symptom of TBI, fatigue was described as a potential barrier to physical activity by nearly all participants, even though they recognised the paradox of improving their overall fatigue through tiring physical activity: *"I was lying in a hospital bed for six weeks … then there was muscle wastage for the next 18 months as I tried to recover. So, I didn't have any strength to do anything, which meant I was always fatigued. I feel if you can improve people's strength and fitness, then they can cope with everyday tasks better. That gives them more energy. Therefore, they're less fatigued…. people don't seem to understand that to alleviate that fatigue, you have to work hard, which makes you more fatigued, but in the long run, you become less fatigued. That's the perception I'd like to change."* (P3) Participants almost universally regarded longer travel times to reach physical activity venues as problematic due to fatigue they would experience even before commencing the physical activity, *"Just the travel would knock me out" (P11)*. Many emphasised the slog and potential threat of getting to and participating in activities with fatigue: *"… virtually every day, I start out knowing I'm depleted before I start…. If I push past points, all the symptoms occur…. You want to participate, but you've got to try to keep a lid on the symptoms or manage them, because you pay price or I do. there's a whole lot of logistics that I never would've had to think about before at all, that now are logistics to ensure I don't have another accident, or hurt myself, or fall over, or any number of bonkers things that can happen when you're exhausted and beyond exhausted."* (P1)	Nil.

	Fatigue could also be compounded by other symptoms that many physical activity venues were likely to exacerbate: *"I can't handle too much stimulus from the outside. So, if … there's a lot going on…. a lot of people moving in different directions…. One, I get physically exhausted. And then secondly, I can't cope with what's going on and I have trouble with directions. Like typically going to a toilet down corridors, left, right, this way, that way, I'll get lost. And that's what I find at the gym too. You just get lost…. my brain almost shuts down and I just freeze."* (P13) **BRIDGES qualitative research with stakeholder groups:** Accessing a community-based gym to participate in muscle strength training, as recommended by the WHO physical activity guidelines, that requires the family to drive the activity may be challenging for them to prioritise, particularly if there are other children and activities to juggle. *"families have got other priorities. So if you gave them that [WHO guideline recommendations] as the guideline, there's no way that they would say that that's something that they would be able to meet, particularly early on in their journey of traumatic brain injury. Maybe many, many years down the track, but definitely not early on."* (Health Professional)	

BALANCE OF EFFECTS

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	Trivial undesirable effects and small desirable effects, based upon the potential for children and adolescents to benefit from muscle strength training similar to adults, and the recommendation from the WHO. On the balance of desirable and undesirable effects, participating in muscle strength training, in particular ballistic exercises, is probably favoured over the alternative (i.e., not participating in muscle strength training).	Nil.

RESOURCES REQUIRED

How large are the resource requirements (costs)?"

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	Cost data is not available from any studies in TBI. The cost of the required resources likely varies depending on the needs of the person with TBI, e.g., if they can independently participate in muscle strength training, or if they need one-on-one supervision or specific equipment to facilitate muscle strength training. **BRIDGES audit of brain injury services:** Six (n = 6) paediatric services across Australia (Location: 3/8 states and territories; all in major cities; 5 public, 1 private; 4 specialist inpatient brain injury rehabilitation, 1 inpatient rehabilitation service that manages some brain injury clients, 1 private practice). Number of sites who have the following equipment for strength training in inpatient and/or outpatient services: Tilt table (6/6; 100%), Handheld weights (5/6; 83%), Cuff weights (5/6; 83%), Bands (5/6; 83%), Jump trainer (3/6; 50%), Weight machines (2/6; 33%), Suspension slings/springs (1/6; 17%), and Weighted vests (1/6; 17%). **BRIDGES qualitative research with people living with TBI:** This work provided insights into costs for muscle strength training post-rehabilitation in the community. The costs of physical activities, transport and equipment and, primarily, variability in insurance coverage, played a very significant role in enabling or obstructing access to different types of physical activity including muscle strength training: *"I get help by the NDIS, so that is a major factor in what exercise I choose to do…. I wouldn't have an exercise physiologist … coming to my house if we weren't getting help. I can guarantee, that's a big deal…. we couldn't afford to be supporting exercise physiology and the gym and all the other stuff if we weren't getting help."* (P3) **BRIDGES qualitative research with stakeholder groups:** It was noted from multiple stakeholders the need for attendant care workers to support participation in physical activity (including muscle strength training) including supporting travel, motivation to do the activity, supervision of home or gym programs. *"I find one of the biggest barriers is if they're wanting to get back to community sport or engage in regular exercise that they may have been participating in prior to their injury and are really motivated to get back to that, some of the barriers around access and appropriate equipment, support to be able to get them there, often they're not driving. I think those things become quite difficult, so it's probably more so around appropriate equipment, access and support for transport."* (Health Professional) It was noted from health professional and community physical activity providers, that specialised/adapted equipment is needed for those with higher support needs that either	Nil.

	needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment. *"There's a whole range of things, like hand cycling and recumbent bikes are a big passion of mine, so I love adapted bikes, that that's a great way to get people engaged, and that's just on a recreational level, and then we've got that cohort that want to go that little bit further and get classified, and then try to go onto the Paralympics or compete, so cool."* (Health Professional)	
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES What is the certainty of the evidence of resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
o Very low o Low o Moderate o High ● No included studies	No studies include cost data about the resources required.	Nil.
COST EFFECTIVENESS Does the cost-effectiveness of the intervention favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
o Favors the comparison o Probably favors the comparison o Does not favor either the intervention or the comparison o Probably favors the intervention o Favors the intervention o Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Nil.
EQUITY What would be the impact on health equity?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	• General population studies have shown lower physical activity levels (likely to include reduced levels of muscle strength) in lower socioeconomic areas (Jerome et al., 2023). Providing an intervention to increase muscle strength will likely benefit those in more disadvantaged groups. • Access to inpatient rehabilitation services is within public health system, so access for all is dependent on need, not funding. • There is likely access to state-based funding and NDIS for any with moderate to severe injury (if meet inclusion criteria) to support muscle strength training post inpatient rehabilitation, but completion of forms etc for access to these funding schemes may be more challenging for those with lower socioeconomic backgrounds or less family support. • National guidelines may support providers to deliver and funders to fund muscle strength training for those living in more regional, rural and remote areas that aren't as linked in with specialist brain injury services.	In two representative cross-sectional population surveys (1985 and 2015) of Australian children aged 9–15 years (n = 7051), larger declines in standing broad jump (an indicator of muscle strength) were observed in children from low socioeconomic neighbourhoods than the declines among children from high SES neighbourhoods (Hardy et al., 2018). According to the Australian Bureau of Statistics (ABS), the proportion of young people (aged 15 - 24) who undertook sufficient muscle strengthening activities was greater in: • Major cities (33%) than in inner regional, outer regional and remote areas combined (20%) • The highest socioeconomic areas than in the lowest socioeconomic areas (39% compared with 25%) (ABS, 2019).

ACCEPTABILITY

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Six paediatric services across Australia were included in the audit: • *Location:* 3/8 states and territories; all in major cities • *Type:* 5 public, 1 private; 4 specialist inpatient brain injury rehabilitation, 1 inpatient rehabilitation service that manages some brain injury clients, 1 private practice. Of the six services, all reported delivering lower extremity strength training, for both very weak and weak muscles as part of their service, which was delivered by physiotherapists (6/6; 100%), allied health assistants (4/6; 67%), and exercise physiologists (1/6; 16%) **BRIDGES qualitative research with stakeholder groups:** In relation to acceptability of the WHO guideline level of physical activity (60-min per day moderate to vigorous physical activity; vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone should be incorporated at least 3 days a week), all stakeholder groups were overall accepting of this but identified that some with more severe injuries (cognitive, behavioural and/or physical impairments) may not be able to meet this level	Nil.

	(intensity and/or duration) or may need additional support/equipment and time to achieve this. *"I think with the right person, the right attitude, the right help, they* (the WHO physical activity guidelines) *could be reached."* (Family member) *"... families have got other priorities. So if you gave them that as the guideline, there's no way that they would say that that's something that they would be able to meet, particularly early on in their journey of traumatic brain injury. Maybe many, many years down the track, but definitely not early on."* (Health Professional) There was good support for gym-based training targeting muscle strength by family members: *"I'm reluctant to give up the one-on-one session, because that's just focusing on his muscle strength and all of that, which is really good."* (Family member) *"So we're trying to add in one session in a class, so it's social. And also, he'll be able to do ... they'll have machines and different props and things there that will mix it up a bit and build a bit more on his strength".* (Family member)	
FEASIBILITY Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Muscle strength training, for both weak and very weak muscles seems feasible in rehabilitation settings when delivered or supervised by health professionals. Most services (4/6; 66%) assessed muscle strength to set training parameters, with all of those using manual muscle testing to achieve this. There was variability between services in strategies used to train strength, dosage and type of strength training. While 4/6 (66%) services refer clients to an external physiotherapist or exercise physiologist for muscle strength training. All the services trained family/support workers to supervise strength training. Barriers identified by the services to delivering lower extremity strength training were mostly in relation to resources (4/6; 66%). **BRIDGES qualitative research with stakeholder groups:** Community-based muscle strength training may require specific resources (e.g., equipment, staff) and appropriate opportunities (e.g., inclusive or disability specific facilities and programs). Funding from state-based funders or NDIS may support this, however it would need to meet	Nil.

	legislative requirements, fit within participant-developed goal and require submission of paperwork. *"The NDIS pays for the support worker to take her to the hydrotherapy. We pay for the pool cost, which, that's only $4 a time."* (Family member) *"the NDIS will fund modified recreational activities including equipment, but you need to clearly show that again it's reasonable and necessary and that what you're asking to do is not something like if you ask just to buy an e-bike, it has to be clearly linked to the fact that it's linked to your disability and what you're on the scheme for.* "(Service funder) *"Give them hope that there is something they can do that actually will work. Then if you get them on a really good weights programme where people actually know what they're doing and not messing around, which is what I see so often, get people to do this properly, then people will get amazing results and you'll change people's lives forever.* "(Exercise provider) *"Well, fortunately, most activities we do, we've had a physiotherapist come out and guide us, so we can do exercises that she can do. Obviously, she's restricted in doing exercises in a normal gym, because they don't cater for that properly.* "(Family member) *"we've got some access to modified gyms, but trying to find gym access, plenty of people just trip over the weights and equipment. If they want to go back into a standard gym, that can be really difficult. And I think that cognition and behaviour, as well as their physical capacity of the actual clients, can become a great barrier. I think cost, we've touched on cost primarily because they often need supervision or assistance or care to be able to participate in something."*(Health Professional) Opportunities to incorporate organised and non-organised physical activities that include functional muscle strengthening exercises relevant to children (i.e., lifting, throwing, jumping) are likely to arise in the school setting. There needs to be a willingness of schools to engage with outside providers (e.g., health professionals) and to see the importance of participating in muscle strengthening activities training as part of the education curriculum for children living with disabilities such as TBI. *"One of the facilitators can be the schooling environment. If you've got the right people in the schooling environment that can help promote physical activity in a way that is enjoyable, successful, meaningful, then that means their participation in those areas can be positively influenced, rather than them sitting out on things or timekeeping or keeping score, any of those terrible things."* (Health Professional)	

SUMMARY OF FINDINGS TABLE, FOREST PLOTS AND RISK OF BIAS ASSESSMENT

No studies measured any of the critical or important outcomes identified for this intervention. Therefore, no summary of findings table, forest plots or risk of bias were completed for this clinical question.

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Clinical question 5: Mobility training for adults and older adults with moderate to severe traumatic brain injury

Clinical question

Should structured **mobility** training (i.e., gait, balance and function training) compared to control be used for **adults and older adults** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home

Perspective: Health systems

Outcomes of interest:

1.	Balance	CRITICAL
2.	Combined mobility	CRITICAL
3.	Walking capacity	CRITICAL
4.	Physical activity	IMPORTANT
5.	Co-morbidities and mortality	IMPORTANT
6.	Participation	IMPORTANT
7.	Quality of life	IMPORTANT

Strong recommendation:

For adults and older adults after moderate to severe traumatic brain injury we recommend task-specific mobility training across the continuum of care.

Good Practice Points

We suggest:

- Mobility training aims to achieve participation-level and activity-level goals established collaboratively.
- The setting and supervision requirements for adults with significant cognitive and/or behavioural impairments is considered to maximise participation in mobility training and the transfer of training to real life tasks.

- Virtual reality interventions and body weight support treadmill training (with or without robotics) may be used as options to train mobility.
- Mobility training is incorporated into weekly routines with key supports (e.g., family, friends, support workers) trained in facilitating this activity where appropriate.
- Mobility training incorporates motor learning principles of task-specific, repetitive intensive practice.

Justification

Overall justification

Reduced mobility is a common problem after TBI with negative consequences. Mobility training is likely to address this problem.

Detailed justification

Problem

Reduced mobility is a common activity limitation after TBI which can reduce participation in everyday activities, as well as have negative physiological and psychological impacts.

Desirable Effects

Mobility training likely to have moderate positive effects on critical outcomes for individuals with TBI including balance, combined mobility and walking capacity.

Balance of effects

Likely desirable effects are moderate and undesirable effects such as adverse events are likely trivial (e.g., muscle soreness). Motor learning principles of task-specific, repetitive, intensive practice are likely to be important for adults and older adults with motor impairments from their TBI.

Acceptability

Good acceptability from multiple stakeholders.

Feasibility

Feasible to deliver in inpatient and post-rehabilitation settings, although implementation support will be needed, especially for services and clinicians working with individuals with higher support needs (including cognitive and behavioural impairments).

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	Very low	Low	**Moderate**	High		No included studies	
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	**Favors the intervention**	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High		**No included studies**	
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

PROBLEM Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	**Evidence in TBI:** Mobility limitations are common after msTBI. It is common for individuals to be admitted to inpatient rehabilitation with mobility limitations. Typically, they will improve while in rehabilitation, but some individuals live with some level of mobility limitation over their lifespan. For example: • An Australian adult cohort study using prospectively collected clinical data over a 13-year period (2000 to 2013; n = 613) found that, on admission to inpatient rehabilitation, 27% could stand up from a chair equal weightbearing, 33% could stand equal weightbearing, 26% could walk at ≥1 m/s independently, 37% could climb stairs and 7% could run. On discharge (median length of stay 52 days, IQR 28 to 129) this improved considerably; 65% could stand up from a chair equal weightbearing, 73% could stand equal weightbearing, 70% could walk at ≥ 1 m/s, 81% could climb stairs, and 33% could run (Wong et al., 2019). • Improvements in physical function have also been shown in older adults with TBI undertaking inpatient rehabilitation (Noel et al., 2023). • Mobility limitations in people with TBI can persist into the long term, with a longitudinal follow-up of patients finding little change in mobility level for participants across a span of ten years (Ponsford et al., 2014) • Higher level mobility skills such as running or jumping are important for participating in social, leisure and sporting activities. A long-term follow up of people living with msTBI found that around 75% of individuals did not resume their pre-injury activities (Ponsford et al., 2014). • "Mobility limitations can have pervasive and extensive physiological and psychological sequalae, and are associated with reduced cardiovascular fitness, increased susceptibility to fatigue and reduced ability to exercise aerobically after TBI, as well as poor emotional health" (Williams et al., 2022) Mobility training is often a focus of physiotherapy management and patient goals in rehabilitation, with a certain level of mobility required for the individual to be discharged home from hospital and to be safe walking in the community (Hassett 2023).	Mobility limitations are caused from primary motor impairments directly due to the brain injury (i.e., weakness, loss of coordination, spasticity, sensory changes), secondary impairments due to the primary impairments and environmental factors (e.g., contracture, pain, cardiorespiratory deconditioning), and other injuries sustained at the same time such as lower limb or vertebral fractures. For example, in the cohort study described by Wong 2019, 325/613 individuals with TBI (53%) had ≥ 1 orthopaedic injury in addition to their TBI.
DESIRABLE EFFECTS How substantial are the desirable anticipated effects?		

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	**Evidence in TBI:** See summary of findings table below. There have been several trials of mobility training conducted among the TBI population, mostly comparing two different types of mobility interventions. This research has not been synthesised in a systematic review to date, however we can descriptively report the following: • A recent topical review (Hassett 2023) synthesised data from four RCTs that compared the effectiveness of different types of walking training. Three of the four studies that compared treadmill training with overground walking included participants who would not be independent walkers, and who were ≥ 1 year after injury; interventions were prescribed to be performed for 30 to 60 minutes, two to three times per week for 4 to 14 weeks. Although overall no difference was found between types of interventions (when comparing mobility training using bodyweight-supported treadmill training versus overground training on 10m walk test (2 RCTs) and Functional Ambulation Category (FAC) outcome (2 RCTs), treadmill training with virtual reality versus overground walking on FAC (1 RCT), and robotic treadmill training versus bodyweight supported treadmill training or overground walking on FAC (1 RCT), most trials reported improvement in both intervention groups for mobility outcomes from baseline to end of intervention. • The same review synthesised data from four RCTs investigating virtual reality balance training compared to other balance training. Three of the four studies included participants ≥ 1 year post-injury and with high-level mobility problems. Interventions were 4-12 weeks long and targeted dynamic standing balance. Virtual reality balance training led to improvements in measures of balance (indicated by Berg Balance Scale and Community Balance and Mobility Scale scores) but were not significantly different to other types of balance training. Similar to the walking studies, both intervention groups improved for balance outcomes from baseline to end of intervention. • Four RCTs have also evaluated providing an additional dose of mobility training in addition to usual rehabilitation or usual activities. These interventions included training of a specific mobility task (e.g., sit to stand, or additional cognitive tasks) as well as combined mobility training. These studies varied in quality (PEDro score ranging from 0 to 8/10) and included adults with TBI at varying times post-injury. Effectiveness of these interventions varied, with some studies demonstrating between-group differences on some outcomes (e.g., sit to stand ability, Timed up and Go Test and some variables for walking), but not others. Overall, these studies provide some evidence for mobility training in individuals with TBI, but the variety of interventions and outcomes make it difficult to be certain of these effects (SMD: 0.2; 95%CI -0.37 to 0.77).	

- Some RCTs compared the effects of mobility training vs. other intervention. These interventions included 6-8 weeks of robotic vs. manually assisted bodyweight support treadmill training (Esquenazi 2013) and 6 weeks virtual reality vs. conventional mobility training (Sveistrup 2003; 3-arm trial). In both studies, participants in both intervention groups demonstrated improvements in mobility outcomes (walking speed and Community Balance and Mobility Scale, respectively), though the magnitude of effect was varied.
- In Kleffelgaard et al. (2019), 65 outpatients (mild to moderate TBI) were randomised to an 8-week group-based vestibular rehabilitation intervention (including balance training) or usual multidisciplinary outpatient rehabilitation. Post-intervention, the vestibular rehabilitation group showed greater improvements compared to the control group in combined mobility (HiMAT).
- Williams 2022 study was described under clinical question 3 and compared ballistic strength training to dose-matched usual care. The usual care group was standardised and was delivered 1hr 3x week for 12 weeks (same amount as ballistic strength training group) and included graded balance (static and dynamic) progressed to ensure challenge, stretching (calf, quads, hamstring, hip adductors), strength (seated-leg press), aerobic (60-80% HRmax up to 10mins on bike or arm ergometer), and gait training (10mins). Mobility outcome (HiMAT) favoured ballistic strength training group [control group improved from 18 (SD12) to 25(SD15) baseline to end intervention]. Walking speed no difference between groups [control group improved 0.98m/s (SD 0.41) to 1.24m/s {SD 0.42) baseline to end intervention]. Balance (timed single leg stance) favoured control group (MD: -1.9secs (95%CI -3.6 to -0.3)) [control group improved 7.1secs (SD 6.2) to 11.7secs (SD 7.7) baseline to end intervention].

Evidence in stroke:

Evidence from Australian and New Zealand Living Clinical Guidelines for Stroke Management:

Strong recommendations:

- For stroke survivors who have difficulty sitting, practising reaching beyond arm's length while sitting with supervision/assistance should be undertaken (Veerbeek et al. 2014).
- For stroke survivors who have difficulty in standing up from a chair, practice of standing up should be undertaken (Pollock et al. 2014; French et al. 2016).
- For stroke survivors who have difficulty with standing balance, standing activities that are functional and challenge balance should be provided (French et al. 2016, van Duijnhoven et al. 2016, Hugues et al. 2019)

	• Stroke survivors with difficulty walking should be given the opportunity to undertake tailored repetitive practice of walking (or components of walking) as much as possible (French et al. 2016). The following modalities may be used: • Circuit class therapy (with a focus on overground walking practice) (Veerbeek et al. 2014). • Treadmill training with or without body weight support (Mehrholz et al. 2014). Community-dwelling stroke survivors with confirmed difficulties in personal or extended activities of daily living should have specific therapy from a trained clinician (e.g., task-specific practice and training in the use of appropriate aids) to address these issues (Legg et al. 2017). *Weak recommendations:* For stroke survivors who have difficulty with standing balance, one or more of the following interventions may be used in addition to practicing functional tasks: • Virtual reality training, which may include treadmill training, motion capture or force sensing devices (e.g. Wii Balance Boards) (Corbetta et al. 2015; Laver et al. 2017; Mohammadi et al. 2019). • Visual or auditory feedback e.g., force platform biofeedback (Veerbeek et al. 2014; Stanton et al. 2017). • Electromechanically assisted gait or standing training (Zheng et al. 2019). For stroke survivors with difficulty walking, one or more of the following interventions may be used in addition to circuit class therapy or treadmill training: • Virtual reality training (Corbetta et al. 2015). • Electromechanically assisted gait training (Mehrholz et al. 2013). • Biofeedback (Stanton et al. 2017). • Cueing of cadence (Nascimento et al. 2015). • Electrical stimulation (Howlett et al. 2015).	

UNDESIRABLE EFFECTS

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Evidence in TBI** Of nine RCTs that reported on adverse events, no adverse events were reported in four of these studies. Esquenazi et al. (2013) included three reports of skin irritations and one of leg pain. Tefertiller et al. (2022) included one report of harness irritation, one of ankle pain, three of knee pain, two of dizziness and one of foot cramping. Kleffelgaard (2019) reported one occurring during mobility testing. Sarkamo et al. (2021) reported that one participant, who had suffered from seizures in the post-injury stage, discontinued the intervention due to the emergence of epileptic seizures.	**Clinical expertise input:** Risk of musculoskeletal injuries as a result of participating in mobility training likely no different to the risk posed to those without TBI with graded volume/intensity and appropriate supervision.

CERTAINTY OF EVIDENCE

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ● Moderate ○ High ○ No included studies	**Evidence in TBI:** See summary of findings table below. Outcomes rated between very low to moderate certainty evidence. **Evidence in Stroke:** For stroke survivors who have difficulty sitting, practising reaching beyond arm's length while sitting with supervision/assistance should be undertaken. • Large effect when reaching beyond arms length (3 RCTs) (Veerbeek et al. 2014). For stroke survivors who have difficulty in standing up from a chair, practice of standing up should be undertaken. • Moderate quality evidence improve time taken to STS & lateral symmetry (13RCTs) (Pollock et al. 2014- Cochrane) • Consistent moderate benefits on STS ability (7 RCTs), (SMD: 0.35, 95%CI 0.13 to 0.56) (French et al. 2016-Cochrane, low certainty evidence). For stroke survivors who have difficulty with standing balance, standing activities that are functional and challenge balance should be provided • Small effect on standing balance (9RCTs SMD: 0.24, 95%CI: 0.07 to 0.42) (French et al. 2016)	It is likely that the same mechanism for improvement after stroke could be achieved after TBI. They are both upper motor neuron lesions with similar impairments post-injury. Differences between TBI and stroke population include: 1) TBI may have additional injuries such as fractures. 2) TBI may be younger than those after stroke (and therefore may have less co-morbidities), however this is changing with increase TBI in older adults after falls. 3) TBI may have more diffuse brain injury, therefore may present with more and varied impairments including behavioural. 4) Severe TBI may spend longer in acute care management before being admitted for rehabilitation, they may therefore have greater secondary impairments such as contracture and reduced fitness.

<table>
<tr><td></td><td>• Moderate effect functional task training vs. no training (SMD: 0.54, 95%CI: 0.32 to 0.75) (16RCTs) (Hugues et al. 2019, low certainty evidence)

Stroke survivors with difficulty walking should be given the opportunity to undertake tailored repetitive practice of walking (or components of walking) as much as possible.

• Small to moderate effect on walking distance and functional ambulation, not speed. Higher dose mod effect, low dose small effect [ns diff] (French et al. 2016, moderate certainty evidence).

Overall evidence decision:

Given the overwhelming evidence on task-specific training after stroke, we have considered indirect evidence from stroke (high to low certainty) and direct evidence in TBI (very low to moderate).</td><td></td></tr>
<tr><td colspan="3">VALUES
Is there important uncertainty about or variability in how much people value the main outcomes?</td></tr>
<tr><td>JUDGEMENT</td><td>RESEARCH EVIDENCE</td><td>ADDITIONAL CONSIDERATIONS</td></tr>
<tr><td>○ Important uncertainty or variability
○ Possibly important uncertainty or variability
● Probably no important uncertainty or variability
○ No important uncertainty or variability</td><td>No specific research has been conducted in TBI to inform the value people living with TBI place on the main outcomes.

BRIDGES qualitative research with people living with TBI:

Mobility training can improve balance, gait and improve an individual's ability to perform higher level mobility tasks such as running and jumping. These are important for improving physical function, as well as having important implications for participation in leisure and sporting activities. Qualitative work as part of the BRIDGES project revealed that people living with TBI value being able to safely participate in activities of their choosing:

"I'd love to be in a team sport again. I miss the team environment, but … I can't run. I can't do this. I can't do that. I know what I can do and I can do that individually…. if I do it on my own, I feel like I can pace myself better and get myself to where I need to go better than in a team. I don't feel like I can give the team what they need." (P20)

"My physical activity … is going to dance festivals where there are several DJs playing in a field or a park and just being free to dance how I want without the fear of hurting myself if I fall over and also not being judged by others who are attending." (P15)

BRIDGES stakeholder focus groups:</td><td>Nil.</td></tr>
</table>

	"We've really got to keep on top of his mobility and his balance because it's hard, anyway, with the vision and the depth perception. So you stop doing that exercises and that practise of standing on one leg and building the strength, everything just goes down." (Family member)	

BALANCE OF EFFECTS Does the balance between desirable and undesirable effects favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ● Favors the intervention ○ Varies ○ Don't know	See the four preceding criteria.	Nil.

RESOURCES REQUIRED How large are the resource requirements (costs)?"		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	• Cost data is not available from any studies in TBI. • Mobility interventions have been conducted in both the home and centre/hospital-based setting. Larger costs associated with mobility training may result from the use of technologies as part of interventions (e.g., virtual reality training, BWSTT, computerised biofeedback systems). **BRIDGES audit of brain injury services:** Of the 21 adult brain injury services that see people with msTBI, the following details the number of sites who have the following equipment for mobility training in inpatient and/or outpatient services: Up/down plinth (95%), walking track (86%), treadmill (100%), bodyweight support harness (62%), robotics (14%), virtual reality (14%), stairs (90%), trampette/mini trampoline (81%), walking frame (81%), walking stick (81%), ankle foot orthoses (95%) and transfer belt (62%). **BRIDGES qualitative research study:**	Nil.

	Costs of physical activities, transport and equipment and, primarily, variability in insurance coverage, played a very significant role in enabling or obstructing access to different types of physical activity: *"I get help by the NDIS, so that is a major factor in what exercise I choose to do…. I wouldn't have an exercise physiologist … coming to my house if we weren't getting help. I can guarantee, that's a big deal…. we couldn't afford to be supporting exercise physiology and the gym and all the other stuff if we weren't getting help."* (P3) **BRIDGES qualitative study with six stakeholder groups:** It was noted from multiple stakeholders the need for attendant care workers to support participation in physical activity including supporting travel, motivation to do the activity, supervision of home or gym programs. *"So one of my clients, she was always really liked swimming, so her mobility with walking out of the pool isn't fantastic, but getting her in the pool and completing walking exercises in there really works for her."* (Support worker) *"I can't go to the gym by myself, because I don't remember what I'm supposed to do with the machines and how I actually do it, so I have to have somebody come with me…. I can't just go walk my dog on my own, because I could fall over. So everything that I do physically now has to have somebody there with me. So I can't even just go for a walk around the block without having somebody there to make sure that I'm okay. So it's a little bit harder…. I can't drive. So anything that I go and do, I have to have somebody to take me there and it's limiting. Public transport where I live is there, but it's hard to get to. So again, I've got to have somebody drive me to get there. So the sort of independence that other people have, I don't have…. If I could get to places … under my own steam, I would be really excited and would go and do things more often. But I just can't. So I have to understand my limitations and be okay with those to then try and see what else I can go and do."* (P2) It was noted from health professional and community physical activity providers, that specialised/adapted equipment is needed for those with higher support needs that either needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment. *"We had a few little places we could refer to around [our area], but nothing with a ceiling harness, for instance, where I could put someone up in a ceiling harness to do gait training and engage them in exercise that way. So there was quite a few limitations, I didn't have all the tools in the box as a therapist, and to have all those tools in the box, it's so cost prohibitive."* (Health Professional)	

CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies include cost data about the resources required.	Costs are likely to vary across care settings. Mobility training would be included as part of inpatient rehabilitation and therefore covered as overall bed day costs. People with more severe injuries will likely need additional resources to achieve good mobility outcomes. E.g., specialised equipment such as standing frames, harness above treadmill only available in disability services, assistance of multiple therapists. Supervision for cognitive and/or behavioural impairments in home or community-based settings to guide following training program. People with injuries due to road traffic accidents or workplace accidents are covered by state insurance schemes. Mobility training including resources (health professionals, assistive technology) may be funded by these funding agencies as long as assessed as “reasonable and necessary” as per legislation. People covered by National Disability Insurance Scheme (NDIS) (<65 years old) may be able to have some funding to support participation in mobility training when identified as a goal by patient.

COST EFFECTIVENESS

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Given the additional costs that may be required in this population, it is difficult to extrapolate data from other populations.
EQUITY What would be the impact on health equity?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	There is no evidence to guide this judgement in TBI research.	Mobility training is delivered as part of inpatient rehabilitation, so access to health practitioners for all people with msTBI is dependent on need rather than funding. People living with msTBI may also have access to funding for formal exercise therapy (including mobility training) post-inpatient rehabilitation through the NDIS or state-based funding. However, processes required to access ongoing funding through these schemes (e.g., the application, participation in consultations and reviews, and follow-up with the funders) may be more challenging for those from lower socioeconomic backgrounds, or those with English as a second language. National guidelines may support providers to deliver and funders to fund mobility training for those living in more regional, rural and remote areas that aren't as linked in with specialist brain injury services.
ACCEPTABILITY Is the intervention acceptable to key stakeholders?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** • 21 adult services audited across Australia, of which 14 saw only working age adults, and the remaining seven saw both working age adults as well as older adults. • *Location*: 8/8 states and territories; 17 major cities, 2 regional and 2 outer regional or remote • *Type:* 14 public, 3 private, and 4 mixed; 8 specialist brain injury services with inpatient service, 6 private practices that work with TBI clients, 3 inpatient rehabilitation services that manage some brain injury clients, 2 outpatient community rehabilitation teams, 1 specialist brain injury services transition/case management, 1 acute neurosurgical ward. • 21/21 (100%) services report delivering functional training to improve mobility as part of their service. • *Who:* In these services functional training is delivered by physiotherapists (21/21; 100%); exercise physiologists (6/21; 29%); allied health assistants (5/21; 24%); occupational therapists (2/21; 9%); and recreational therapists (1/21; 4%).	Nil.
FEASIBILITY Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Functional mobility training seems feasible in adult rehabilitation settings when delivered or supervised by health professionals and given the access to suitable equipment for mobility training. The most common measures to assess mobility outcomes were 10MWT (21/21); 6MWT (20/21); HiMAT (20/21); Timed standing balance (18/21); TUG (18/21); 5x STS (17/21); Berg Balance Scale (16/21); Dynamic Gait Index (8/21); Functional Gait Assessment (7/21); Functional Reach Test (7/21); Motor Assessment Scale (6/21); and MiniBEST Test (4/21). Only 8/21 (38%) services refer clients to an external physiotherapist or exercise physiologist for mobility training. All the services trained family/support workers to supervise mobility training. Barriers identified by the services to delivering mobility training included resources (9/21); time (3/21); and safety (3/21). **BRIDGES qualitative study with six stakeholder groups:** It should be considered that specific equipment and skills may be required to cater for the individual capabilities of each person living with TBI. These resources may be limited in some clinical setting. This was highlighted in the stakeholder focus group:	Nil.

	"So one of my clients, she was always really liked swimming, so her mobility with walking out of the pool isn't fantastic, but getting her in the pool and completing walking exercises in there really works for her." (Support worker) *"We had a few little places we could refer to around [our area], but nothing with a ceiling harness, for instance, where I could put someone up in a ceiling harness to do gait training and engage them in exercise that way. So there was quite a few limitations, I didn't have all the tools in the box as a therapist, and to have all those tools in the box, it's so cost prohibitive."* (Health Professional) *"Consistent access to appropriate facilities would be one of the biggest barriers for me, and I think stemming from that would be transport to, consistent support work, access to and costs of accessing gyms and how that gets funded, all those sorts of things."* (Health Professional)	

SUMMARY OF FINDINGS TABLE

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured gait/balance/function training	control	Relative (95% CI)	Absolute (95% CI)		
Balance (Virtual reality balance training vs. other balance training) (follow-up: range 4 weeks to 12 weeks; assessed with: Berg Balance Scale, Community Balance and Mobility Scale)												
4	randomised trials	serious[a]	not serious	not serious	very serious[b]	none	61	56	-	SMD **0.27 SD higher** (0.17 lower to 0.71 higher)	⨁◯◯◯ Very low	CRITICAL
Balance (non-ballistic exercise vs. ballistic resistance training (dose-matched) (follow-up: range 12 weeks to 24 weeks; assessed with: Timed single leg stance test (secs))												
1	randomised trials	not serious	not serious	not serious	serious[c]	none	See strength clinical question: Non-ballistic exercise (including balance + gait training) was superior than ballistic resistance exercise for improving balance at end of intervention (MD 2secs more (95%CI 3.67 more to 0.33 more). At follow-up 12 weeks later, it remained superior, but was not statistically significant (MD 1.2 secs more; 95%CI 3.25 more to 0.85 less).				⨁⨁⨁◯ Moderate	CRITICAL
Combined mobility (Additional mobility training vs. control) (assessed with: maximum number of sit-to-stand, Balance Evaluation System Test, Community Balance and Mobility Scale, Berg Balance Scale)												
4	randomised trials	serious[d]	not serious	not serious	very serious[b]	none	30	29	-	SMD **0.2 SD higher** (0.37 lower to 0.77 higher)	⨁◯◯◯ Very low	CRITICAL
Combined mobility (Partial weightbearing training vs. traditional physical therapy) (follow-up: 8 weeks; assessed with: Rivermead Mobility Index)												
1	randomised trials	serious[e]	not serious	not serious	very serious[b]	none	19	19	-	MD **0.82 higher** (2.3 lower to 3.94 higher)	⨁◯◯◯ Very low	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured gait/balance/function training	control	Relative (95% CI)	Absolute (95% CI)		
Combined mobility (high-level mobility) (Additional group-based vestibular rehabilitation vs. usual multidisciplinary outpatient rehabilitation) (follow-up: 8 weeks; assessed with: HiMAT (0 to 54; higher is better))												
1	randomised trials	serious[f]	not serious	not serious	serious[g]	none	29	23	-	MD **6.4 higher** (0.8 higher to 12 higher)	⨁⨁◯◯ Low	CRITICAL
Combined mobility (control (non-ballistic exercises (including balance + gait)) vs. ballistic resistance exercise, HiMAT 0-54, higher better) (follow-up: range 12 weeks to 24 weeks; assessed with: HiMAT (0 to 54, higher is better))												
1	randomised trials	not serious	not serious	not serious	serious[c]	none	See strength clinical question: Mobility outcome (HiMAT) favoured ballistic strength training group change from baseline to end of intervention (MD: -3 (95%CI -6.09 to 0.09) [control group improved from 18 (SD12) to 25(SD15) baseline to end intervention]. Similar results change from baseline to follow-up (MD: -3 (95%CI -6.86 to 0.86))				⨁⨁⨁◯ Moderate	CRITICAL
Walking capacity (walking speed) (Bodyweight-support treadmill training vs. overground walking) (follow-up: range 4 weeks to 14 weeks; assessed with: 10mWT)												
2	randomised trials	serious[h]	not serious	not serious	very serious[b]	none	21	19	-	MD **0.05 SD lower** (0.27 lower to 0.16 higher)	⨁◯◯◯ Very low	CRITICAL
Walking capacity (walking speed) (control (non-ballistic exercise (including balance + gait) vs. ballistic resistance exercise, (follow-up: range 12 weeks to 24 weeks; assessed with: 10MWT, m/s)												
1	randomised trials	not serious	not serious	not serious	serious[c]	none	See strength clinical question: No difference between groups for change in walking speed over 10m from baseline to end of intervention (MD: -0.01 (95%CI -0.12 to 0.10) or from baseline to end of follow-up (MD: -0.01 (0-14 to 0.12). Both groups changed from baseline to end of intervention by ~ 0.28m/s and from baseline to end of follow-up by ~ 0.35m/s.				⨁⨁⨁◯ Moderate	CRITICAL
Physical activity												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured gait/balance/function training	control	Relative (95% CI)	Absolute (95% CI)		
0								0	-	**0** (0 to 0)	-	IMPORTANT
Participation (Virtual reality home exercise program vs. traditional home exercise program) (follow-up: 6 weeks; assessed with: Participation Assessment with Recombined Tools- Objective)												
1	randomised trials	serious[i]	not serious	not serious	very serious[b]	none	31	32	-	MD **0.08 lower** (0.23 lower to 0.07 higher)	⨁◯◯◯ Very low	IMPORTANT
Comorbidities and mortality												
0							0/0	0/0	not estimable		-	IMPORTANT

CI: confidence interval; **MD:** mean difference; **SMD:** standardised mean difference

EXPLANATIONS

a. Participants and personnel delivering the intervention unable to be blinded, no allocation concealment any studies, no blinding assessor 1/4 studies, concerns regarding selective reporting.

b. Small sample size, confidence intervals include favouring control intervention.

c. wide confidence intervals.

d. Participants and personnel delivering the intervention unable to be blinded, concerns regarding selective reporting, no concealed allocation 2/4 studies, no assessor blinding 2/4 studies.

e. Participants and personnel delivering the intervention unable to be blinded, concerns regarding selective reporting.

f. Participants and personnel delivering the intervention unable to be blinded.

g. small sample size.

h. Participants and personnel delivering the intervention unable to be blinded, concerns regarding blinding of outcome assessment and selective reporting, no concealed allocation.

i. Participants and personnel delivering the intervention unable to be blinded, concerns regarding selective reporting.

FOREST PLOTS AND RISK OF BIAS ASSESSMENT

Outcome: Balance

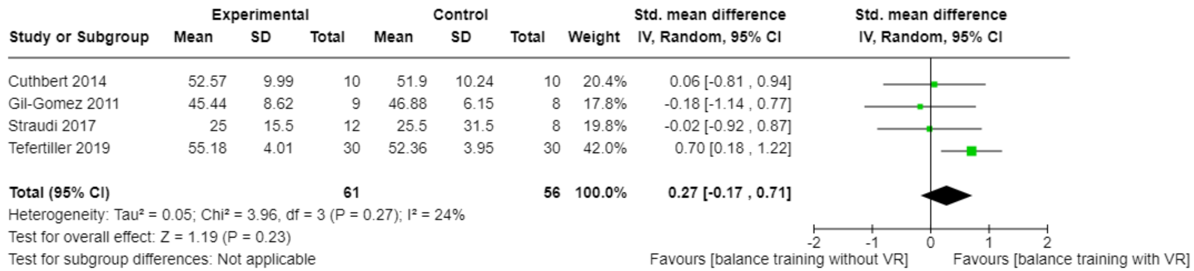
Balance at end of intervention: (balance training with virtual reality vs other balance exercises)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Cuthbert 2014	+	+	-	+	NA	+	-	+
Gil-Gomez 2011	+	-	-	+	NA	+	-	+
Straudi 2017	+	-	-	-	NA	+	-	+
Tefertiller 2019	+	-	-	+	NA	+	+	+

<u>Note:</u> Tefertiller 2019: PEDro 5/10, Clinical Trial Registration No: NCT01794585; Gil-Gomez 2011: PEDro 6/10; Cuthbert 2014: PEDro 6/10; Straudi 2017: PEDro 5/10, Clinical Trial Registration No: NCT01883830.

- Forest plot (from Hassett 2023, JOP):



Balance change from baseline to end of intervention: (non-ballistic exercises [including balance + gait] vs. ballistic resistance exercise- dose matched)

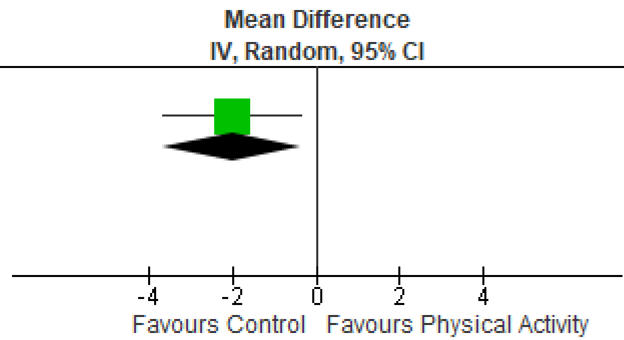
- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	NA	+	+	+

- Forest plot: Single-leg stance time (0 to 30-seconds)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.7.1 SLS time (s)								
Williams 2022	3	4.2	62	5	5.5	69	100.0%	-2.00 [-3.67, -0.33]
Subtotal (95% CI)			**62**			**69**	**100.0%**	**-2.00 [-3.67, -0.33]**

Heterogeneity: Not applicable
Test for overall effect: Z = 2.35 (P = 0.02)



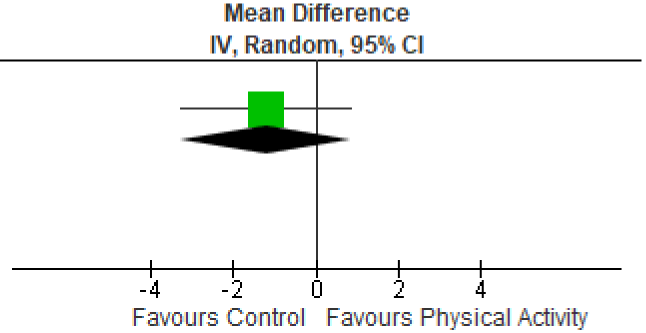
Balance from baseline to end of follow-up: (non-ballistic exercises [including balance + gait] vs. ballistic resistance exercise- dose matched)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	NA	+	+	+

- Forest plot

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.8.1 SLS time (s)								
Williams 2022	3.8	4.8	56	5	6.3	58	100.0%	-1.20 [-3.25, 0.85]
Subtotal (95% CI)			**56**			**58**	**100.0%**	**-1.20 [-3.25, 0.85]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.15 (P = 0.25)								



Outcome: Combined mobility

Combined mobility (Additional dose of mobility training vs. control; assessed with maximum number of STS, Balance Evaluation System Test, Community Balance and Mobility Scale, Berg Balance Scale)

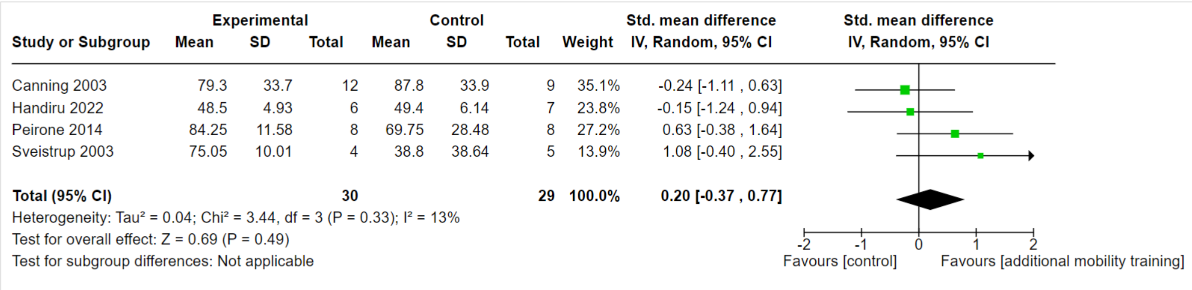
- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Canning 2003	+	+	-	+	NA	+	-	+
Handiru 2022	+	-	-	-	NA	-	-	+

Peirone 2014	+	+	-	+	NA	+	-	+
Sveistrup 2003	+	-	-	-	NA	-	-	+

<u>Note:</u> Canning 2003: PEDro 7/10; Handiru 2022: no PEDro score; Peirone 2014: PEDro: 8/10; Sveistrup 2003: PEDro 0/10.

- Forest plot:



Combined mobility (Partial body weight support treadmill training vs. traditional therapy measured using RMI; 0-15, higher is better).

- Risk of bias

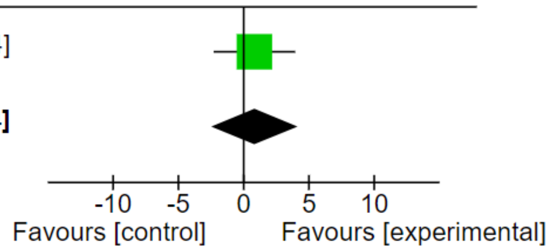
	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Wilson 2006	+	+	-	+	?	+	-	+

- Forest plot:

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean difference IV, Random, 95% CI
Wilson 2006	7.76	5.17	19	6.94	4.63	19	100.0%	0.82 [-2.30 , 3.94]
Total (95% CI)			**19**			**19**	**100.0%**	**0.82 [-2.30 , 3.94]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.52 (P = 0.61)
Test for subgroup differences: Not applicable

Mean difference IV, Random, 95% CI



Combined mobility (vestibular rehabilitation (including balance training) vs. usual multidisciplinary outpatient rehabilitation; measured using HiMAT; 0-54, higher is better.

- Risk of bias

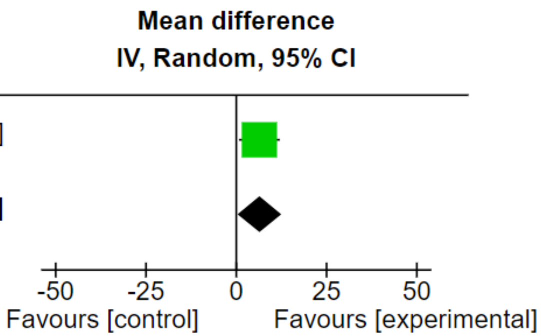
	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Kleffelgaard 2019	+	+	-	+	NA	+	?	+

<u>Note:</u> *Kleffelgaard 2019 Clinical Trials Registry (#NCT01695577)*

- Forest plot:

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean difference IV, Random, 95% CI
Kleffelgaard 2019	47.6	7	29	41.2	12.3	23	100.0%	6.40 [0.76 , 12.04]
Total (95% CI)			**29**			**23**	**100.0%**	**6.40 [0.76 , 12.04]**

Heterogeneity: Not applicable
Test for overall effect: Z = 2.23 (P = 0.03)
Test for subgroup differences: Not applicable



Combined mobility at end of intervention and follow-up: (control (non-ballistic exercises (including balance + gait)) vs. ballistic resistance exercise, HiMAT 0-54, higher better)

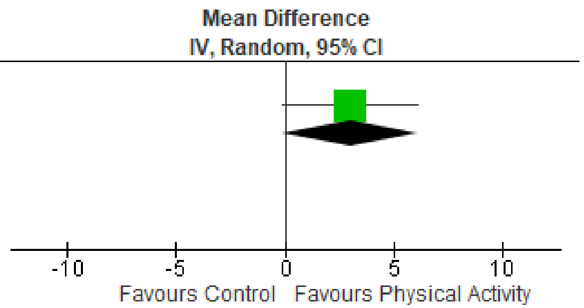
- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

- Forest plot change from baseline to end of intervention: HiMAT (0 to 54 points)

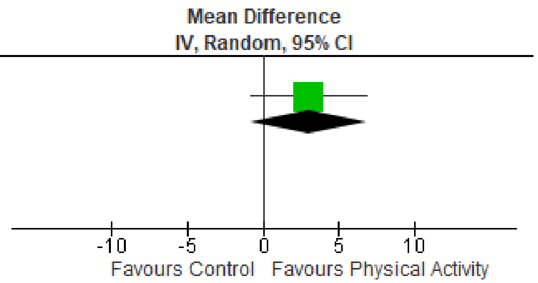
Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.3.1 HiMAT								
Williams 2022	11	9	62	8	9	69	100.0%	3.00 [-0.09, 6.09]
Subtotal (95% CI)			**62**			**69**	**100.0%**	**3.00 [-0.09, 6.09]**

Heterogeneity: Not applicable
Test for overall effect: Z = 1.90 (P = 0.06)



- Forest plot change from baseline to end of follow-up: HiMAT (0 to 54 points)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.4.1 HiMAT								
Williams 2022	14	11	56	11	10	58	100.0%	3.00 [-0.86, 6.86]
Subtotal (95% CI)			**56**			**58**	**100.0%**	**3.00 [-0.86, 6.86]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.52 (P = 0.13)								



Outcome: walking capacity

Walking speed (body weight support treadmill training vs. overground walking at end of intervention, 10MWT, m/s):

- Risk of bias:

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Brown 2005	+	-	-	-	NA	+	-	+
Tefertiller 2022	+	-	-	+	NA	+	-	+

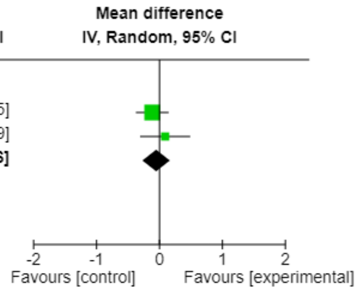
Note: Brown 2005: PEDro 5/10; Tefertiller 2022: PEDro 6/10, 3-arm trial, only treadmill training vs. standard of care groups included, trial registration number 1606744.

- Forest plot (from Hassett 2023, JOP):

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean difference IV, Random, 95% CI
2.1.1 BWSTT vs. overground walking- 10MWT (m/s)								
Brown 2005	0.328	0.241	10	0.443	0.326	9	70.1%	-0.11 [-0.38 , 0.15]
Tefertiller 2022	1.12	0.47	11	1.03	0.46	10	29.9%	0.09 [-0.31 , 0.49]
Subtotal (95% CI)			**21**			**19**	**100.0%**	**-0.05 [-0.27 , 0.16]**

Heterogeneity: Tau² = 0.00; Chi² = 0.71, df = 1 (P = 0.40); I² = 0%
Test for overall effect: Z = 0.48 (P = 0.63)

Test for subgroup differences: Not applicable



Walking speed at end of intervention and follow-up: (control (non-ballistic exercises (including balance + gait)) vs. ballistic resistance exercise, HiMAT 0-54, higher better)

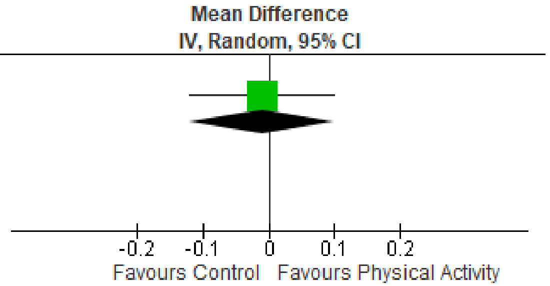
- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Williams 2022	+	+	-	+	+	+	+	+

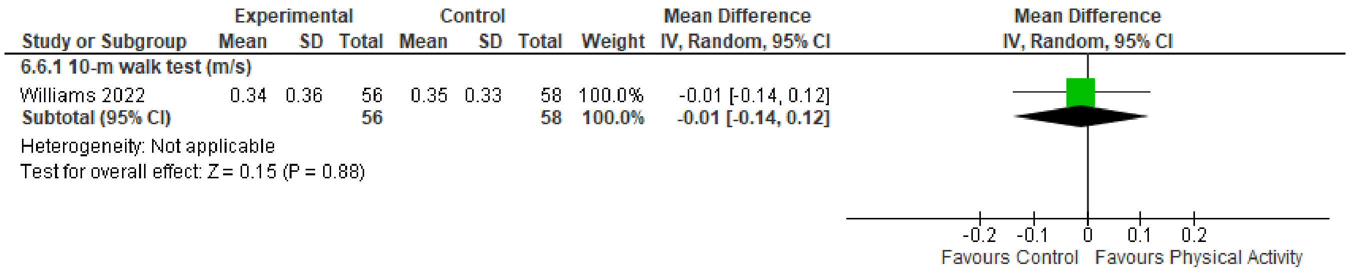
- Forest plot change from baseline to end of intervention

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
6.5.1 10-m walk test (m/s)								
Williams 2022	0.27	0.34	62	0.28	0.29	69	100.0%	-0.01 [-0.12, 0.10]
Subtotal (95% CI)			**62**			**69**	**100.0%**	**-0.01 [-0.12, 0.10]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.18 (P = 0.86)



- Forest plot change from baseline to end of follow-up



Outcome: Participation

Participation measured using the Participation Assessment with Recombined Tools-Objective (PART-O)

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Tefertiller 2019	+	-	-	+	NA	+	+	+

Note: Tefertiller 2019: PEDro 5/10, Clinical Trial Registration No: NCT01794585.

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Clinical question 6: Mobility training for children and adolescents with moderate to severe traumatic brain injury

Clinical question

Should structured **mobility** training (i.e., gait, balance and function training) compared to control be used for **children and adolescents** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home
- Schools

Perspective: Health systems

Outcomes of interest:

1.	Balance	CRITICAL
2.	Combined mobility	CRITICAL
3.	Walking capacity	CRITICAL
4.	Physical activity	IMPORTANT
5.	Co-morbidities and mortality	IMPORTANT
6.	Participation	IMPORTANT
7.	Quality of life	IMPORTANT

Conditional recommendation:

For children and adolescents after moderate to severe traumatic brain injury, we suggest task-specific mobility training across the continuum of care.

Good Practice Points:

We suggest:

- Mobility training aims to achieve participation-level and activity-level goals established collaboratively where the child's voice is at the centre.

- The setting and supervision requirements for children with significant cognitive and/or behavioural impairments is considered to maximise participation in mobility training and the transfer of training to real life tasks.
- Mobility training is incorporated into weekly routines with key supports (e.g., siblings, friends, teachers, support workers, and parents) trained in facilitating this activity.
- Mobility training is performed when the child is and isn't fatigued to enable practice of mobility at different capacities.
- Mobility training is delivered within an interdisciplinary model to enable management of any psychosocial impairments and/or adjustments to injury that may impact on training.
- Mobility training incorporates motor learning principles of task-specific, repetitive, intensive practice.

Justification

Overall justification

Reduced mobility is a common problem after TBI with negative consequences. Mobility training is likely to address this problem.

Detailed justification

Problem

Reduced mobility is a common activity limitation after TBI which can reduce participation in everyday activities including school, sport and recreation. As well as having negative physical consequences, this can limit social opportunities for children, negatively impacting their psychological wellbeing.

Desirable Effects

Although low certainty, mobility training may have positive effects on critical outcomes for individuals with TBI such as combined mobility and walking capacity.

Balance of effects

Likely desirable effects with a lack of TBI-specific information on undesirable effects. Motor learning principles of task-specific, repetitive, intensive practice are likely to be important for children and adolescents with motor impairments from their TBI.

Acceptability

Good acceptability from multiple stakeholders.

Feasibility

Feasible to deliver in inpatient and post-rehabilitation settings, although implementation support will be needed, especially for services and clinicians working with individuals with higher support needs.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

CRITERIA	SUMMARY OF JUDGEMENTS						
PROBLEM	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
DESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large	Varies	Don't know	
UNDESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large	Varies	Don't know	
CERTAINTY OF EVIDENCE	Very low	**Low**	Moderate	High	No included studies		
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	**Moderate costs**	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High	**No included studies**		
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
FEASIBILITY	No	Probably no	**Probably yes**	Yes	Varies	Don't know	

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

PROBLEM Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Children and adolescents commonly experience reduced mobility following TBI. The recovery of mobility skills is important in supporting children's participation in their community (Bedell et al., 2004; Fragala et al., 2002). It is also important for participation in physical activity, which promotes social opportunities and has benefits for physical and psychological wellbeing (Sallis et al., 2000). Most children with TBI regain the ability to walk independently, however experience ongoing mobility limitations due to impaired balance, speed, coordination, and fitness. These impairments impact a child's ability to perform high-level mobility skills (e.g., running, skipping and hopping), which may restrict their participation in typical childhood sport and play (Kissane et al., 2015). Previous research showed that when comparing high-level mobility in children with TBI against healthy controls, the mean HiMAT score for the TBI cohort was 36.1/54, compared to 45.6/54 in the healthy control group. This difference is indicative of significantly greater mobility limitations in children with TBI (Kissane et al., 2015).	Nil.

DESIRABLE EFFECTS How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Evidence in TBI:** See summary of findings table below. There is very limited research investigating the effect of a mobility intervention on identified outcomes of importance in children and adolescents after msTBI. In a non-RCT design, Drijkoningen et al. (2015) investigated the effect of home-based computer assisted balance training on balance (as indicated by performance on the Sensory Organization Test (SOT), Limits of Stability (LOS) Test and Rhythmic Weight Shift test (RWS) over eight weeks. Three groups were included: children with TBI undergoing intervention, typically developing children undergoing the intervention and typically developing children without intervention. There was a significant increase in performance on the SOT from pre to post intervention in the TBI group. Both groups experienced an increase in performance on the RWS and LOS test from pre to post test. In a pre-post study design, deKloet et al. (2012) investigated the effect of 12 weeks of goal-oriented Nintendo Wii training on physical activity and participation. Participants experienced an increase in intensity of the reported amount of time spent in physical activity over 12 weeks.	**Evidence in children with cerebral palsy:** In a systematic review (Novak et al., 2019), the following recommendations were made: • strong recommendation for goal-directed training based on low quality evidence for improved gross motor function. • weak recommendation for mobility training based on low quality evidence for improved gross motor function. • strong recommendation for mobility training based on moderate quality evidence for improved walking speed. • Although there are similarities between children and adolescents with mild CP and TBI, there are also important differences that need to be considered when considering suitability of evidence in CP for TBI. Some differences include children with CP may have more motor impairments without impairments in

	The study reported significant differences over time in the diversity of recreational activities and the intensity of physical activities. In the Katz-Leurer et al. (2009) RCT, the authors report on the effect of 6 weeks of home-based task-oriented exercise compared to a control group on the effect of mobility. They reported a change score of -1.6s on the timed-up-and-go test, and 0.04m/s based on the 10mWT. In the Baque et al 2017 RCT, the authors report on the effect of 20 weeks of home-based web-based multimodal therapy programme individually tailored from 12 available modules including; (1) gross motor (sit-to stands, squats, lunges, aerobic and balance tasks); (2) combined cognitive and visual perception; and (3) upper limb activities vs. waitlist control. The MitiiTM group demonstrated significantly greater improvements on combined score of functional strength tests (mean difference 10.19 repetitions; 95% confidence interval, 3.26–17.11; p = 0.006; not considered clinically significant) compared with the control group. There were no other between-group differences on secondary outcomes including walking capacity, combined mobility and physical activity. deKloet et al. (2012), Katz-Leurer et al. (2009) and Baque (2017) include generally small samples sizes of a mix of traumatic and non-traumatic brain injured children and adolescents mostly above the age of 8-years, highlighting uncertainty of the evidence for the effect of mobility training in children and adolescents after msTBI. **Evidence in childhood stroke:** Consensus based recommendation from Australian childhood stroke guidelines (2019): "Goal-directed therapy incorporating motor learning principles (including task-specific, repetitive and intensive practice) should be considered to improve motor difficulties after childhood stroke."	executive functioning, and children with TBI may be the opposite.

UNDESIRABLE EFFECTS

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

● Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Evidence in TBI:** There is limited evidence of adverse events (AEs) or serious adverse events (SAEs) as a result of mobility intervention in children and adolescents after msTBI. Katz-Leurer et al. (2009) reported there were no adverse effects experienced during their home-based task-oriented exercise training intervention, while deKloet et al. (2009), Drijkoningen et al. (2015) and Baque 2017 did not report on the incidence of AEs or SAEs.	**Clinical expertise input:** Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken. Risk of falls when participating in challenging balance and gait activities that may cause an injury. **Evidence in children with cerebral palsy:** Pooled analysis across five systematic reviews investigating mobility training for improved gross motor function indicated a low risk of harms (Novak et al., 2019).

CERTAINTY OF EVIDENCE

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ● Low ○ Moderate ○ High ○ No included studies	See summary of findings table below. All outcomes rated as very low or low certainty evidence.	**Evidence in children with cerebral palsy:** The certainty of evidence for mobility training for improved gross motor function was low across five systematic reviews (Novak et al., 2019). The certainty of evidence for improved walking speed was very low for one RCT and moderate across two meta-analyses.

VALUES

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted to inform the value children and adolescents with TBI (or their family) place on the main outcomes. **BRIDGES qualitative research with people living with TBI:** Mobility training can improve balance, gait and improve an individual's ability to perform higher level mobility tasks such as running and jumping. These are important for improving physical function, as well as having important implications for participation in leisure and	If mobility training can enable the child or adolescent to participate in activities with their peers, it is likely to be of value to them.

	sporting activities. Qualitative work as part of the BRIDGES project revealed that people living with TBI value being able to safely participate in activities of their choosing: *"I'd love to be in a team sport again. I miss the team environment, but ... I can't run. I can't do this. I can't do that. I know what I can do and I can do that individually.... if I do it on my own, I feel like I can pace myself better and get myself to where I need to go better than in a team. I don't feel like I can give the team what they need."* (P20) **BRIDGES stakeholder focus groups:** Other impairments, such as cognition and visual disturbance, experienced by children and adolescents after msTBI, may present as barriers to the individual to completing their rehabilitation: *"we've really got to keep on top of his mobility and his balance because it's hard, anyway, with the vision and the depth perception. So you stop doing that exercises and that practise of standing on one leg and building the strength, everything just goes down" (Family member)*	

BALANCE OF EFFECTS

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	Lack of reporting on undesirable effects and limited, variable desirable effects on critical and important outcomes. On balance, improvements in mobility can increase capacity to participate in meaningful activities with family and peers. Although adverse events are poorly reported, most likely undesirable effect is a non-injurious fall. In addition, knowledge on neural plasticity informs neurological rehabilitation that recommends task-specific, repetitive motor retraining.	Nil.

RESOURCES REQUIRED

How large are the resource requirements (costs)?"

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings	Cost data is not available from any studies in TBI. The cost of the required resources likely varies depending on the needs of the person with TBI, e.g., if they can independently	Nil.

○ Large savings ○ Varies ○ Don't know	participate in mobility training, or if they need one-on-one supervision or specific equipment to facilitate mobility training. **BRIDGES audit of brain injury services:** All six (n = 6) brain injury services that see children and adolescents after msTBI have the following equipment for mobility training in inpatient and/or outpatient services: Up/down plinth, treadmill, bodyweight support harness, stairs, trampette/mini-trampoline, and ankle foot orthoses. Other equipment less commonly reported to be used by the services include walking frames (5/6; 83%), walking sticks (4/6; 67%), transfer belt (4/6; 67%), walking track (4/6; 67%), and virtual reality (1/6; 17%). No services reported having access to or using robotics. **BRIDGES qualitative research with people living with TBI:** Given that some children and adolescents after msTBI require increased support and resources to safely participate in mobility training, there may be higher costs involved. Costs of physical activities, transport and equipment and, primarily, variability in insurance coverage, played a very significant role in enabling or obstructing access to different types of physical activity including mobility training: *"I get help by the NDIS, so that is a major factor in what exercise I choose to do…. I wouldn't have an exercise physiologist … coming to my house if we weren't getting help. I can guarantee, that's a big deal…. we couldn't afford to be supporting exercise physiology and the gym and all the other stuff if we weren't getting help."* (P3) **BRIDGES qualitative research with stakeholder groups:** It was noted from health professionals and funders that specialised/adapted equipment is needed for those with higher support needs that either needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment: *"There's a really wonderful local allied health provider that has EPs, physios and OTs, and they have a hub here that has all modified equipment. So someone living with a TBI that has a lot of mobility concerns, they can go there and they can access all the equipment.* (Service funder) *"we had a few little places we could refer to around [our area], but nothing with a ceiling harness, for instance, where I could put someone up in a ceiling harness to do gait training and engage them in exercise that way. So there was quite a few limitations, I didn't have all the tools in the box as a therapist, and to have all those tools in the box, it's so cost prohibitive."* (Health Professional)	

CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES What is the certainty of the evidence of resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies include cost data about the resources required.	Costs are likely to vary across care settings. There is evidence from the BRIDGES health services audit that all brain injury services that see children and adolescents after msTBI deliver mobility training to inpatients, which may therefore be covered as overall bed day costs. Children and adolescents with more severe injuries will likely need additional resources to participate in mobility training to support safety and accessibility, including supervision for cognitive and/or behavioural impairments in home or community-based settings to support and guide their engagement in mobility training.

COST EFFECTIVENESS Does the cost-effectiveness of the intervention favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Nil.

EQUITY What would be the impact on health equity?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased	• Access to inpatient rehabilitation services is within public health system, so access for all is dependent on need, not funding. • There is likely access to state-based funding and NDIS for any with moderate to severe injury (if meet inclusion criteria) to support mobility training post inpatient	Nil.

○ Increased ○ Varies ○ Don't know	rehabilitation, but completion of forms etc for access to these funding schemes may be more challenging for those with lower socioeconomic backgrounds or less family support. • National guidelines may support providers to deliver and funders to fund aerobic training for those living in more regional, rural and remote areas that aren't as linked in with specialist brain injury services.	

ACCEPTABILITY

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	**Evidence from TBI:** There were mostly good rates of participant retention in the few studies investigating mobility training in children and adolescents after msTBI. • deKloet et al. (2012) reported that 45/50 participants completed the intervention. Reasons for dropout included a lack of time due to school, removal and lack of motivation. • Katz-Leurer et al. (2009) reported that 9/10 participants completed the intervention. One participant dropped out due to travel time. • Drijkoningen et al. (2015) reported that 15/19 TBI participants completed the intervention. Reasons for dropout included a lack of time and the high physical load. • Baque et al. (2017) participants in the intervention group completed an average of 17.57 hours (SD 14.85) of MitiiTM training (range 0–46.14 hours) across an average of 52.68 logins (SD 39.98). Parents reported that the frequency and daily duration was too long and difficult to maintain. **BRIDGES audit of brain injury services:** Six (n = 6) brain injury services that see children and adolescents after msTBI were included in the national audit. • *Location:* 3/8 states and territories; all in major cities. • *Type:* Five public services, one private; four specialist inpatient brain injury rehabilitation, one inpatient rehabilitation service that manages some brain injury clients, and one private practice. • All of the six services included in the audit reported delivering functional training to improve mobility as part of their service.	Nil.

	• *Who:* The services reported the functional training was delivered by physiotherapists (6/6; 100%), allied health assistants (4/6; 67%), OT (1/6; 17%), and family (1/6; 17%).	
FEASIBILITY Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	There is limited research to support the feasibility of mobility training for children and adolescents after msTBI. Baque (2017) found some challenges with providing a web-based home program with parents reporting technology errors. They also reported drop-off in compliance after four weeks and hypothesised could be related to technology issues, also children with more cognitive and behavioural impairments may need more structure such as centre-based or school-based program. **BRIDGES audit of brain injury services:** Mobility training seems feasible in paediatric rehabilitation settings when delivered or supervised by health professionals. • All services report using the 6-minute walk test and High-level Mobility Assessment Tool (HiMAT) to assess mobility, and 5/6 services report using the 10-metre walk test, berg balance scale, timed-up-and-go, and timed standing balance to assess mobility. The 5-times sit-to-stand test was used by 4/6 services included in the audit. • Four of the six services reported referring clients to an external physiotherapist for mobility training, while all services trained family/support workers to supervise functional mobility training. • Barriers identified by the services to delivering mobility training were mostly in relation to resources. **BRIDGES qualitative research with stakeholder groups:** Specific equipment and skills may be required to cater for the individual capabilities of each person living with TBI. These resources may be limited in some clinical setting. This was highlighted in the stakeholder focus group:	Limited research has been conducted in those with high support needs, and Indigenous and culturally and linguistically diverse populations. Additional work on implementation of mobility training in these groups is needed to ensure suitability, acceptability, and effective way to deliver this intervention.

	"So one of my clients, she was always really liked swimming, so her mobility with walking out of the pool isn't fantastic, but getting her in the pool and completing walking exercises in there really works for her." (Support worker) *"we had a few little places we could refer to around [our area], but nothing with a ceiling harness, for instance, where I could put someone up in a ceiling harness to do gait training and engage them in exercise that way. So there was quite a few limitations, I didn't have all the tools in the box as a therapist, and to have all those tools in the box, it's so cost prohibitive."* (Health Professional) *"consistent access to appropriate facilities would be one of the biggest barriers for me, and I think stemming from that would be transport to, consistent support work, access to and costs of accessing gyms and how that gets funded, all those sorts of things."* (Health Professional)	

SUMMARY OF FINDINGS TABLE

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured gait/balance/function training	control	Relative (95% CI)	Absolute (95% CI)		
Balance (Home-based balance program in TBI vs healthy control) (follow-up: 8 weeks)												
1	observational studies	very serious[a]	not serious	not serious	serious[b]	none	48 young participants (19 children with TBI undergoing intervention, 19 typically developing children undergoing intervention, 10 typically developing children with no intervention). On the Sensory Organization Test, there was a significant increase from pre- to post-test for the TBI-t group and a trend towards a significant increase from pre- to post-test for the TD-t group. In the Rhythmic Weight Shift test, a significant increase was evident in the TBI-t group and TD-t group from pre- to post-test. In the Limits of Stability test, there was a significant increased from pre-to post-test in both groups. No significant changes were observed in the TD-c group for any of the three postural control tasks.				⨁◯◯◯ Very low	CRITICAL
Combined mobility (Additional home-based task-oriented exercise vs control group) (follow-up: range 6 weeks to 20 weeks; assessed with: Timed up and go (shorter time is better))												
2	randomised trials	serious[c]	not serious	not serious	serious[d]	none	Home exercise program (n=10, including 5 children with TBI) • At baseline: 10.1s • Change score after 6 weeks: -1.6s Control group (n=10, including 5 children with TBI) • At baseline: 8.1s • Change score after 6 weeks: 0s RCT2: (Baque 2017) MD: -0.5 (95%CI -0.52 to 0. 41)				⨁⨁◯◯ Low	CRITICAL
Walking capacity (Additional home-based task-oriented exercise vs control group) (follow-up: mean 20 weeks; assessed with: 6 minute walk test, metres (higher better))												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	structured gait/balance/function training	control	Relative (95% CI)	Absolute (95% CI)		
1	randomised trials	serious[e]	not serious	not serious	serious[f]	none	25	26	-	MD **9.13 metres higher** (17.12 lower to 35.38 higher)	⊕⊕◯◯ Low	CRITICAL
Physical activity (Goal-oriented Nintendo Wii training) (follow-up: 12 weeks; assessed with: Time spent on physical activity)												
1	observational studies	very serious[g]	not serious	not serious	very serious[h]	none	Baseline (n=43): mean physical activity score= 2 (SD:2) (30 to 59mins per week). End of intervention (n=43): physical activity score =3 (SD:2) (60 to 119mins per week)				⊕◯◯◯ Very low	IMPORTANT
Participation (Goal-oriented Nintendo Wii training) (follow-up: 12 weeks; assessed with: Children's Assessment of Participation and Enjoyment)												
1	observational studies	very serious[i]	not serious	not serious	very serious[j]	none	43 participants following 12 weeks of goal-oriented Nintendo Wii training reported an increase in intensity of the reported amount of time spent in physical activity over 12 weeks. The study reported significant differences over time in the diversity of recreational activities and the intensity of physical activities.				⊕◯◯◯ Very low	IMPORTANT
Comorbidities and mortality												
0							0/0	0/0	not estimable		-	IMPORTANT
Physical activity (follow-up: mean 20 weeks; assessed with: Stepcount per day (higher better))												
	randomised trials	serious[e]	not serious	not serious	serious[f]	none	21	21	-	MD **505.33 Step count per day lower** (1569.55 lower to 558.89 higher)	⊕⊕◯◯ Low	IMPORTANT

CI: confidence interval; **MD:** mean difference

EXPLANATIONS

a. No attempt to control for confounding factors that may impact results.

b. small sample size.

c. Participants and personnel delivering the intervention unable to be blinded, risk of selective outcome reporting. Assessor not blinded for either study.

d. Small sample size.

e. Participants and personnel delivering the intervention unable to be blinded, risk of selective outcome reporting, assessor not blinded.

f. Small sample size.

g. No attempt to control for confounding factors that my impact results.

h. small sample size.

i. No attempt to control for confounding factors that my impact results.

j. small sample size.

RISK OF BIAS ASSESSMENT

Outcome: Balance

Balance (home based program in TBI vs. healthy control; follow-up 8 weeks)

- Risk of bias (ROBINS-I)

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
Drijkoningen 2015	-	+	+	+	?	-	+	-

Outcome: Combined mobility

Two RCTs including children with acquired brain injuries measured combined mobility using Timed Up and Go test (TUG) (Katz-Leurer 2009 and Baque 2017). It was not possible to combine data in meta-analysis due to the way it was presented in the publications.

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Baque 2017	+	+	-	-	NA	+	-	+
Katz-Leurer 2009	+	+	-	-	NA	+	-	+

Note: Baque 2017 PEDro score: 5/10; ANZCTR number: 12613000403730; Katz-Leurer 2009 PEDro score: 7/10.

Outcome: Walking capacity

One RCT (Additional home-based task-oriented exercise vs control group, follow-up 20 weeks post intervention assessed with six minute walk test, meters (higher score is better). Analysis taken from publication.

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Baque 2017	+	+	-	-	NA	+	-	+

Outcome: Physical activity

One RCT (Additional home-based task-oriented exercise vs control group, follow-up 20 weeks post intervention assessed with step count per day, (higher score is better). Analysis taken from publication.

One NRSI (Goal-oriented Nintendo Wii training, follow-up 12 weeks post intervention, assessed with time spent on physical activity). Analysis taken from publication.

- Risk of bias

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Baque 2017	+	+	-	-	NA	+	-	+
	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
De Kloet 2012	-	+	+	+	?	-	+	-

Outcome: Participation

One NRSI (Goal-oriented Nintendo Wii training, follow-up 12 weeks post intervention, assessed with the Children's Assessment of Participation and Enjoyment (CAPE)). Analysis taken from publication.

- Risk of bias

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
De Kloet 2012	-	+	+	+	?	-	+	-

Outcome: Comorbidities and mortality

Not measured.

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Clinical question 7: Sport and physical recreation for adults and older adults with moderate to severe traumatic brain injury

Clinical question

Should **sport and physical recreation** compared to control be used for **adults and older adults** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home

Perspective: Health systems

Outcomes of interest:

1.	Social connection	CRITICAL
2.	Participation	CRITICAL
3.	Mood	CRITICAL
4.	Physical activity	IMPORTANT
5.	Co-morbidities and mortality	IMPORTANT
6.	Quality of life	IMPORTANT
7.	Cardiorespiratory fitness	IMPORTANT

Conditional recommendation:

For adults and older adults after moderate to severe TBI, we suggest participation in sport[1] and physical recreation[2] across the continuum of care considering their personal preference and capability.

Good Practice Points:

We suggest:

[1] "an activity involving physical exertion, skill and/or hand-eye coordination as the primary focus of the activity, with elements of competition where rules and patterns of behaviour governing the activity exist formally through organisations" (ABS, 2008).

[2] "an activity or experience that involves varying levels of physical exertion, prowess and/or skill, which may not be the main focus of the activity and is voluntarily engaged in by an individual in leisure time for the purpose of mental and/or physical satisfaction" (ABS, 2008).

- Health professionals consider what sport and/or physical recreation the adult enjoyed and participated in prior to their brain injury when developing their rehabilitation program. Pre-injury activities may be a facilitator or may cause distress if physical, cognitive, or behavioural impairments restrict participation.
- Health professionals consider all aspects of the inclusion spectrum[3] when suggesting options for sport and/or physical recreation.
- Health professionals establish relationships and work with external service providers to facilitate access and opportunities for their clients to participate in sport and/or physical recreation.
- Health professionals support the adult to facilitate participation in sport and/or physical recreation, including supporting preparation of funding requests, and identifying modifications, support and adaptive or specialised equipment necessary to ensure the safety and appropriateness of the activity.

Precautionary points:

- A knock to the head from sport participation may cause a second brain injury. Risk vs. benefit should be considered and discussed by the interdisciplinary team and advice provided to the adult and their family (if appropriate).

[3] The inclusion spectrum is about viewing inclusion in sport and physical recreation activities along a spectrum. A version of the Inclusion Spectrum was devised by the Australian sports Commission (ASC). It includes no modifications, minor modifications, major modifications, primarily for people with disability, only for people with disability.

Justification

Overall justification

Physical inactivity is highly prevalent and problematic for adults and older adults after msTBI. Sport and physical recreation programs can provide opportunities to be physically active in a safe, social, and supportive environment.

Detailed justification

Problem

Adults and older adults after msTBI experience low levels of physical activity, which is associated with higher rates of comorbid conditions and mortality. Adults and older adults after TBI often don't return to pre-injury leisure activities, including sport and recreation.

Balance of effects

On the balance of small desirable and small undesirable effects, and little uncertainty about the value of the main outcomes, participating in sport and physical recreation is probably favoured over the alternative.

Resources required

The cost of the required resources likely varies depending on the needs and wants of the adult after msTBI.

Acceptability

Adults and older adults after msTBI are accepting of the World Health Organisation (WHO) guidelines recommended levels of 150-300-min of moderate-vigorous physical activity, but additional support/equipment may be needed to achieve this.

Feasibility

Likely feasible in rehabilitation and community-based settings when delivered or supervised by health professionals, but further work on implementation is needed to ensure suitability, acceptability, and effectiveness on delivering these interventions.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High		No included studies	
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	**Varies**	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High		**No included studies**	
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

Criteria
Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Meeting the physical activity guidelines (i.e., 150-300-min/week) is associated with a 19%–25% lower risk of all-cause mortality, cardiovascular disease and non-cardiovascular disease mortality (Lee, et al., 2022). People living with TBI generally have decreased participation in leisure and social activities after injury compared to pre-injury baseline and exhibit inadequate levels of physical activity (Hamilton et al., 2016; Wise et al., 2010; Reavenall et al., 2010). People living with msTBI experience higher rates of comorbid conditions, which are associated with higher rates of mortality (Izzy et al., 2022). The risk of social isolation, low mood and reduced life satisfaction are heightened by physical inactivity (Schrempft et al., 2019)	Sport is "an activity involving physical exertion, skill and/or hand-eye coordination as the primary focus of the activity, with elements of competition where rules and patterns of behaviour governing the activity exist formally through organisations" (ABS, 2008). Physical recreation is "an activity or experience that involves varying levels of physical exertion, prowess and/or skill, which may not be the main focus of the activity and is voluntarily engaged in by an individual in leisure time for the purpose of mental and/or physical satisfaction" (ABS, 2008).

Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Evidence from TBI:** The evidence informing this judgement comes from a combination of randomised controlled trials (RCTs) and non-randomised studies of interventions (NRSIs). Interventions investigated were tai chi, yoga and a mixed sport and physical activity program. Of the seven outcomes identified as critical or important, four (i.e., social connection, participation, comorbidities and mortality, and cardiorespiratory fitness) were not measured in any of the studies included. Sport and physical recreation had variable effect on mood. For two RCTs, we pooled the immediate effect of sport and physical recreation on mood data (Center for Epidemiologic Studies Depression scale (Hwang et al., 2020) and the General Health Questionnaire (Blake et	Nil.

	al., 2009)). The meta-analysis indicated the intervention had a small reduction on depression, but this was not significant (two studies, 71 participants; SMD=-0.22; 95% CI -1.25 to 0.81; I2=73%; very low certainty evidence). In the Pérez-Rodríguez et al. (2021) non-randomised study of a sport and physical recreation intervention, participants allocated to the intervention experienced a small reduction on depression compared to control participants, but this was not significant (one study, 67 participants; MD -0.26, 95% CI -0.74 to 0.23; very low certainty evidence). There was no clear long-term effect of sport and physical recreation on mood (one study, 51 participants; MD 1.10, 95% CI -4.31 to 6.51; very low certainty evidence). One NRSI measured the effect of a sport and physical recreation intervention on time in sedentary behaviour, which might be considered as a proxy measure of physical activity (i.e., less time in sedentary behaviour = more time spent physically active). Participants allocated to the intervention reported less time in sedentary behaviour compared to control participants at end of intervention (one study, 62 participants; MD -104mins/day, 95% CI -195.27 to -12.73; very low certainty evidence) (Pérez-Rodríguez, 2021). Quality of life was measured at end of intervention in one RCT (Gemmell et al., 2006) and two NRSI (Donnelly et al., 2017; Pérez-Rodríguez et al., 2021). In the RCT, participants allocated to the intervention improved their quality of life compared to control participants, though the confidence intervals and small sample size indicate uncertainty and suggest imprecision around the estimate of effect (one study, 18 participants; SMD=0.50; 95% CI -0.44 to 1.45; very low certainty evidence). In the two NRSI, participants allocated to the intervention improved their quality of life compared to the control participants (two studies, 88 participants; SMD=0.61; 95% CI 0.18 to 1.05; very low certainty evidence). **Evidence from stroke:** There is insufficient evidence to suggest yoga is an effective intervention for improving health outcomes after stroke (Lawrence et al., 2017) (Cochrane review, including 2 RCTs and 79 participants). However, a systematic review (21 studies, 1,293 participants) found Tai Chi can have positive effects on walking ability, balance and mobility in stroke rehabilitation (Lyu et al., 2018).	
Undesirable Effects How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Evidence from TBI:** See summary of findings table below. No negative effects found on any of the critical or important outcomes. Adverse events (AEs) were not explicitly mentioned in all studies. No serious adverse events (SAEs) were reported in any study. In the Blake et al. (2009) RCT, no AEs were recorded in either group, and in the Pérez-Rodríguez et al. (2021) NRSI, the authors reported that no AEs occurred during the mixed sport and physical activity intervention sessions, and no participants reported secondary problems or complications arising from their activities. In the Donnelly et al. (2021) NRSI, some participants described experiencing dizziness, nausea, discomfort, and/or cognitive fatigue, even when the yoga poses were modified to avoid the exacerbation of symptoms. In the Quilico et al. (2022) scoping review exploring community-based physical activity interventions for people living with msTBI, no adverse events were reported from the studies included in the review. Though only two of 19 included studies reported on the incidence of AEs. **Evidence from stroke:** People with stroke experience very few adverse events in physical fitness interventions (i.e., aerobic exercise, muscle strengthening) (Saunders et al., 2020).	**Clinical expertise input:** Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken. Risk of people with msTBI experiencing musculoskeletal injuries as a result of participating in sport and physical recreation likely no different to the risk posed to those without TBI.
Certainty of evidence What is the overall certainty of the evidence of effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
● Very low ○ Low ○ Moderate ○ High ○ No included studies	See Summary of Findings table.	See additional considerations above.
Values		

Is there important uncertainty about or variability in how much people value the main outcomes?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted in TBI to inform the value people with msTBI place on the main outcomes. However, a qualitative exploration into the community exercise experiences of people living with severe TBI highlights the importance of community-based sport and physical recreation programs. Participants in the research spoke positively on the perceived physical and psychosocial benefits of community-based exercise programmes, and the impact of such programmes on reintegrating with the community and engaging in what the participants perceived as 'productive activity' (Quilico et al., 2021). **BRIDGES qualitative research with people living with TBI:** Participants were looking for a balance of challenge and achievement that suited their capabilities and preferences. For many, the physiological and cognitive challenges associated with new activities, or heightened physical activity, could be overwhelming and needed to be managed carefully or avoided: *"... you've got this inner limitation that you can't control those symptoms, and for me, there are things like dizziness, loss of balance, vomiting, nausea... extreme exhaustion, my vision starts going, can't think... It's almost like a nasty cycle. I've tried to not go there ... because I've learnt pushing through takes me to that place that isn't enabling my body to improve."* (P1) Although all participants were currently engaged in physical activity, they were keenly aware of losses and the need to reinvent themselves as active people. Consequently, there were mixed views about taking part in physical activities they enjoyed pre-injury: *"I'd love to be in a team sport again. I miss the team environment, but ... I can't run. I can't do this. I can't do that. I know what I can do and I can do that individually.... if I do it on my own, I feel like I can pace myself better and get myself to where I need to go better than in a team. I don't feel like I can give the team what they need."* (P20) *"I would love to be able to go and do all those sporting things again, I just would need to find somewhere that is accepting of my issues ... and isn't going to just put me in the too-hard basket."* (P2) *"I think doing sports regardless, whether it's para sports, it's a way of getting closer to being whatever normal is or getting closer to that past life, or that pre-accident stage."* (P18)	Nil.

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	See summary of findings table below. Small undesirable effects and small desirable effects, though the evidence informing this judgement is of very low quality. On the balance of desirable and undesirable effects, participating in sport and physical recreation for individuals who indicate an interest in participating in this type of physical activity is probably favoured over the alternative (i.e., not participating in sport and physical recreation).	Nil.

Resources required

How large are the resource requirements (costs)?"

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies ○ Don't know	Cost data is not available from any studies in TBI. The cost of the required resources likely varies depending on the needs and wants of the person with msTBI. For example, if the person with TBI is able to independently participate in a low-cost sport or physical recreation, such as walking, then the resource requirements are likely minimal. If, however, they need one-on-one supervision or specific equipment to facilitate their sport or physical recreation e.g., ski equipment, and ski pass, then the resource requirements are likely larger. **BRIDGES audit of brain injury services:** Of the 21 adult Australian services that prescribe and promote sport and physical recreation to adults after msTBI, the following equipment is used as part of their rehabilitation in inpatient, transition and community settings: Sporting equipment (i.e., balls, bats, hoops, goals, hurdles) (6/21; 28%), facilities (i.e., running track, courts, nearby park) (2/21; 9%), gym equipment (i.e., treadmill, weights) (4/21; 19%), adaptive equipment (i.e., wheelchairs, fishing equipment) (2/21; 9%), equipment for water-based therapy, such as floatation supports (2/21; 9%).	Nil.

	BRIDGES qualitative research with stakeholder groups: It was noted from multiple stakeholders the need for attendant care workers to support participation in physical activity (including sport and recreation) including supporting travel, motivation to do the activity, supervision of home or gym programs. It was also noted from health professionals and community physical activity providers, that specialised/adapted equipment is needed for those with higher support needs that either needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment: *"Archery is a huge one for our guys, particularly if they're wheelchair bound. There's ways that we can set up archery to only have unilateral involvement with stands or adaptive devices. Lawn bowls is a huge one, adaptive devices now. We have guys that go on fishing boats in wheelchairs and have adaptive devices to use a fishing rod singe-handedly. There's a whole range of things, like hand cycling and recumbent bikes are a big passion of mine, so I love adapted bikes, that that's a great way to get people engaged, and that's just on a recreational level, and then we've got that cohort that want to go that little bit further and get classified, and then try to go onto the Paralympics or compete, so cool."* (Health Professional)	
Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies include cost data about the resources required.	Costs are likely to vary across care settings. There is evidence from the BRIDGES health services audit that some health services deliver sport and physical recreation to inpatients, which may therefore be covered as overall bed day costs. People with more severe injuries will likely need additional resources to participate in sport and physical recreation to support safety and accessibility, including supervision for cognitive and/or behavioural impairments in home or community-based settings to support and guide their engagement in sport and physical recreation. People with injuries due to road traffic accidents or workplace accidents are covered by state insurance schemes. Sport and physical recreation programs including resources may be funded

		by these funding agencies as long as assessed as "reasonable and necessary" as per legislation. People covered by NDIS (<65 years old) may be able to have some funding to support participation in sport and physical recreation when identified as a goal by patient.
Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Given the additional costs that may be required in this population, it is difficult to extrapolate data from other populations. The cost of inactivity, with respect to the burden on the health system associated with chronic disease as a result of physical inactivity, is likely to outweigh the costs of participating in sport and physical recreation. Physical inactivity is responsible for 2.5% of total disease burden in Australia, in 2018 (AIHW, 2021), and is causally linked to the burden from type 2 diabetes, bowel cancer, dementia, coronary heart disease and strokes, as well as uterine and breast cancer in females (AIHW, 2021).
Equity What would be the impact on health equity?		

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	General population studies have shown lower physical activity levels in lower socioeconomic areas (Jerome 2023). Providing access to sport and physical recreation interventions will likely benefit those in more disadvantaged groups. Access to inpatient rehabilitation services is within public health system, so access for all is dependent on need, not funding. There is likely access to state-based funding and NDIS for any with moderate to severe injury (if meet inclusion criteria) to support fitness training post inpatient rehabilitation, but completion of forms etc. for access to these funding schemes may be more challenging for those with lower socioeconomic backgrounds or less family support.	Limited research has been conducted in those with high support needs, children, and Indigenous and cultural and linguistically diverse (CALD) populations.

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**Evidence from TBI studies:** Drop-out rates varied across studies but were not significantly different between intervention and control groups and overall were not high. Adherence to sport and physical recreation intervention was generally good, ranging from 80% attendance to a mixed sport and physical activity program (Pérez-Rodríguez et al., 2021) to 72.5% attendance to a community-based Tai Chi Qigong intervention. **BRIDGES audit of brain injury services:** Of the 21 brain injury services audited across Australia, 14 saw only working age adults, while the remaining seven saw both working age adults as well as older adults. *Location:* 8/8 states and territories; 17 major cities, two regional and two outer regional or remote. *Type:* 14 public, three private, and four mixed brain injury services were included in the audit. These include: eight specialist brain injury services with inpatient service, six private practices that work with TBI clients, three inpatient rehabilitation services that manage some brain injury	Sport and physical recreation are physical activities suitable for people of all ages and abilities (WHO, 2018). Sport and physical recreation can be modified or use equipment to enable the participation of people with disabilities in either mainstream or disability-specific activities (Kiuppis, 2018). The inclusion spectrum includes options for participation in sport and recreation (Kiuppis, 2018): *(1) Separate Activity:* Special activities, specially thought for and proposed for people with disability and practised in different times and spaces. *(2) Parallel Activity:* Disabled athletes may need to train separately with disabled peers to prepare for a competition, such as a wheelchair basketball group included in a local basketball club.

	clients, two outpatient community rehabilitation teams, one specialist brain injury services transition/case management, and one acute neurosurgical ward. Of the 21 adult services audited, 10 (48%) services report delivering sport and physical recreation as part of their service. This was delivered by physiotherapists (10/21; 47%); exercise physiologists (5/21; 24%); sport and recreational therapists (4/21; 19%); OTs (2/21; 9%); and allied health assistants (2/21; 9%). Of the 26 adult and paediatric services audited, there was variability in referral by health professionals to community-based sport and recreation opportunities always, frequently or sometimes: 18/26 refer to community fitness centre. 10/26 community recreation groups (ABI specific). 16/26 community recreation groups (disability specific). 18/26 community recreation groups (mainstream). 6/26 community sport programs (ABI specific). 7/26 community sport programs (disability specific). 1/26 community sport programs (mainstream). **BRIDGES qualitative research with people living with TBI:** Although all participants were currently engaged in physical activity, there were mixed views about taking part in physical activities they enjoyed pre-injury. Some simply did not feel they had the option: *"I'd love to be in a team sport again. I miss the team environment, but … I can't run. I can't do this. I can't do that. I know what I can do and I can do that individually…. if I do it on my own, I feel like I can pace myself better and get myself to where I need to go better than in a team. I don't feel like I can give the team what they need."* (P20) However, for some, the familiarity of the activity was secondary, the key issue was simply being engaged in physical activity: *"I think doing sports regardless, whether it's para sports, it's a way of getting closer to being whatever normal is or getting closer to that past life, or that pre-accident stage."* (P18)	*(3) Disability Sport Activity:* Reverse integration whereby non-disabled children and adults are included in disability sport together with disabled peers. *(4) Open (inclusive) Activity:* Everyone does the same activity with minimal or no adaptations to the environment or equipment; open activities are by their nature inclusive so that the activity suits every participant. *(5) Modified Activity:* Activities designed for all, with specific adaptations to space, tasks, equipment and people's teaching.

	And the challenge of physical activity could undermine their confidence by highlighting disability: *"Prior brain injury I loved sport, I could run, I could play many sports well. I used to love physical activity. After my injury I could not do it, I was good at basketball, hence I tried wheelchair basketball but failed miserably at that…. even after knowing previously the rules it would become overwhelming and I failed…. It's hard enough trying to accept your disability and … that just crushed me."* (P15) Many saw physical activities as a good place for social interactions, to the extent that it could be a deciding factor in choosing to try a new activity: *"… for me too, it was a way of connecting, particularly looking for team sports. I was trying to connect with people from being so isolated, being in rehab and having this injury and going from somebody that's very able bodied to being very dependent on other people. So having connections outside, I think that was a big draw card for me."* (P18) However, for some, the desire to engage in physical activity with others was tempered by the need to focus on personal capabilities and goals: *"I only get individual stuff because I can only control what I can control…. I'd love to be in a team sport again. I miss the team environment, but …I can't run. I can't do this. I can't do that. I know what I can do and I can do that individually, but I don't feel like I could be a good team player…. if I do it on my own, I feel like I can brace myself better and get myself to where I need to go better than in a team. I don't feel like I can give the team what they need."* (P20) Many participants delighted in physical activities that enabled them to feel free of the confines of TBI and noted the psychological benefits of 'escapist' and 'normalising' activity: *"… physical activity] is escapism as well…. mental health merges with physical benefits…. And for me that's, yeah, it's a chance for escapism and freeing [from] being blocked indoors. And that's not just physically indoors, but also your mind, I think."* (P18) *"I can think while I'm walking …and so the walking and the exercise gives me a sense of peace and a sense of freedom that I don't feel at any other time…. When I'm exercising it's the only time I feel normal."* (P4) *"[Exercise] is about the only time for me I do feel normal. Even if it's hard doing it and hard sustaining it, I feel heaps better from it."* (P1) *"I love the feeling of liberation in the water. I love when I get in the pool, nobody knows I'm disabled. I love swimming."* (P6)	

	A number of participants spoke about 'fitting in', and how it related to identity: not only avoiding stigma and judgement, but also of accepting a level of disability and connecting with people who "get it". Disability-specific group activities had the edge in facilitating this sense of belonging: *"I didn't want to go to disability [team] sport because I didn't want to be stereotyped because I was trying to assimilate into mainstream. I wanted to be seen as normal even though, clearly, society didn't see me as normal. [But] now I'm more for it because you feel like you are [playing] against your tribe with your tribe. Not that you're going to find somebody with exactly the same injuries, but there's just that unspoken understanding."* (P18) *"With the crew that does the wheelchair basketball, like all of us there are very inclusive and it's like a good bunch of people and just makes the whole activity more enjoyable because everyone's real respectful and aware of each other's different abilities."* (P11) *"I can think of arguments for why it would be great to be in an exercise group with people who are mainstream, but I can think of probably more arguments for why I think it's better for a long-term commitment to my exercise regime if it's people who I know are also from a traumatic history."* (P12) **BRIDGES qualitative research with stakeholder groups:** In relation to acceptability of the World Health Organisation (WHO) guidelines levels of 150-300-min moderate to vigorous physical activity, all stakeholder groups were overall accepting of this but identified that some with more severe injuries (cognitive, behavioural and/or physical impairments) may not be able to meet this level (intensity and/or duration) or may need additional support/equipment to achieve this. It was suggested resources that provide examples of how a range of different people after TBI meet these levels would be useful. It was also noted that the good practice points of the WHO guideline were very important.	
Feasibility Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	A scoping review by Quilico et al (2022) found community-based physical activity interventions, including aquatic programs, yoga, tai chi, to be feasible and acceptable. Included studies demonstrated feasibility and acceptability via measures of adverse events, program satisfaction and rates of participant recruitment, attendance, frequency of ongoing symptoms, and adherence.	Limited research has been conducted in those with high support needs, children, and Indigenous and CALD populations. Additional work on implementation of sport and physical recreation in these groups is needed to ensure suitability, acceptability, and effective way to deliver these interventions.

	BRIDGES audit of brain injury services: Seems feasible in rehabilitation settings when delivered or supervised by health professionals. There are inconsistencies in the current delivery e.g., only 10/21 (48%) services audited report delivering sport and/or physical recreation, though almost all of these (i.e., 8/21; 38%) link clients with external services/providers to deliver sport and/or physical recreation activities, including disability-specific sporting organisation (i.e., Disability Sports Australia) (6/21; 28%) or a local community gym/group (4/21; 19%). Barriers identified by services to delivering sport and physical recreation include resources (13/21; 62%); lack of appropriate community services (5/21; 24%); knowledge (4/21; 19%); and concerns of safety (4/21; 19%). **BRIDGES qualitative research with stakeholder groups:** Participants noted the feasibility of various sport and physical recreation opportunities given access to adaptive equipment and support: *"Archery is a huge one for our guys, particularly if they're wheelchair bound. There's ways that we can set up archery to only have unilateral involvement with stands or adaptive devices. Lawn bowls is a huge one, adaptive devices now. We have guys that go on fishing boats in wheelchairs and have adaptive devices to use a fishing rod singe-handedly. There's a whole range of things, like hand cycling and recumbent bikes are a big passion of mine, so I love adapted bikes, that that's a great way to get people engaged, and that's just on a recreational level, and then we've got that cohort that want to go that little bit further and get classified, and then try to go onto the Paralympics or compete, so cool."* (Health Professional) *"I find one of the biggest barriers is if they're wanting to get back to community sport or engage in regular exercise that they may have been participating in prior to their injury and are really motivated to get back to that, some of the barriers around access and appropriate equipment, support to be able to get them there, often they're not driving. I think those things become quite difficult, so it's probably more so around appropriate equipment, access and support for transport."* (Health Professional) **BRIDGES qualitative research with people living with TBI:** Several participants who attended mainstream recreation classes talked about the need to educate facilitators about brain injury impacts and their individual needs, but this could be hard to do, especially in classes with a changing group of attendees: *"Sometimes [I say] "Hang on, I can't do this. Can you give me something modified so I can do it?" Every now and then if there's some other people there I don't know, who aren't usually in our class, I feel a bit inhibited because I don't want to feel like I'm just being a nuisance. But [if I don't speak out] I'm not going to get the same amount [of value] out of the class."* (P18)	

	Disability-specific group activities had the edge in facilitating this sense of belonging: *"I didn't want to go to disability [team] sport because I didn't want to be stereotyped because I was trying to assimilate into mainstream. I wanted to be seen as normal even though, clearly, society didn't see me as normal. [But] now I'm more for it because you feel like you are [playing] against your tribe with your tribe. Not that you're going to find somebody with exactly the same injuries, but there's just that unspoken understanding."* (P18) *"With the crew that does the wheelchair basketball, like all of us there are very inclusive and it's like a good bunch of people and just makes the whole activity more enjoyable because everyone's real respectful and aware of each other's different abilities."* (P11) *"I can think of arguments for why it would be great to be in an exercise group with people who are mainstream, but I can think of probably more arguments for why I think it's better for a long-term commitment to my exercise regime if it's people who I know are also from a traumatic history."* (P12) It would be individuals are supported when trying new activities to manage any adaptations and challenges. *"Prior brain injury I loved sport, I could run, I could play many sports well. I used to love physical activity. After my injury I could not do it, I was good at basketball, hence I tried wheelchair basketball but failed miserably at that…. even after knowing previously the rules it would become overwhelming and I failed…. It's hard enough trying to accept your disability and … that just crushed me."* (P15)	

SUMMARY OF FINDINGS TABLE

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	sport and physical recreation	control	Relative (95% CI)	Absolute (95% CI)		
Social connection - not measured												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	sport and physical recreation	control	Relative (95% CI)	Absolute (95% CI)		
-	-	-	-	-	-	-	-	-	-	-	-	CRITICAL
Participation - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	CRITICAL
Mood at end of intervention (sport and physical recreation vs. no intervention or non-active control) (follow-up: range 8 weeks to 6 months; assessed with: Change scores: Centre for Epidemiologic Studies Depression scale (1 study); The General Health Questionnaire (1-study). Lower = better)												
2	randomised trials	very serious[a]	very serious[b]	serious[c]	serious[d]	none	33	38	-	SMD **0.22 SD lower** (1.25 lower to 0.81 higher)	⊕◯◯◯ Very low	CRITICAL
Mood at end of intervention (sport and physical recreation vs. no intervention) (follow-up: mean 18 weeks; assessed with: Post-intervention difference: Beck Depression Inventory II. Lower = better; Scale from: 0 to 63)												
1	observational studies	very serious[e]	not serious	serious[f]	serious[g]	none	39	28	-	SMD **0.26 SD lower** (0.74 lower to 0.23 higher)	⊕◯◯◯ Very low	CRITICAL
Mood at end of follow-up (sport and physical recreation vs. no intervention) (follow-up: mean 12 months; assessed with: Change scores: Centre for Epidemiologic Studies Depression scale. Lower = better; Scale from: 0 to 60)												
1	randomised trials	serious[h]	not serious	serious[i]	serious[j]	none	22	29	-	MD **1.1 higher** (4.31 lower to 6.51 higher)	⊕◯◯◯ Very low	CRITICAL
Physical activity at end of intervention (sport and physical recreation vs. no intervention) (follow-up: mean 18 weeks; assessed with: Time in sedentary behaviour measured with the Global Physical Activity Questionnaire. Lower = better)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	sport and physical recreation	control	Relative (95% CI)	Absolute (95% CI)		
1	observational studies	very serious[k]	not serious	serious[f]	serious[g]	none	34	28	-	MD **104 minutes fewer** (195.27 fewer to 12.73 fewer)	⊕◯◯◯ Very low	IMPORTANT
Comorbidities and mortality - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	IMPORTANT
Quality of life at end of intervention (sport and physical recreation vs. non intervention) (follow-up: mean 3 weeks; assessed with: SF-36 Physical Health summary scale. Higher = better)												
1	randomised trials	very serious[l]	not serious	serious[m]	serious[j]	none	9	9	-	SMD **0.5 SD higher** (0.44 lower to 1.45 higher)	⊕◯◯◯ Very low	IMPORTANT
Quality of life at end of intervention (sport and physical recreation vs. no intervention or non-active control) (follow-up: range 8 weeks to 18 weeks; assessed with: Adapted version of the Quality-of-Life After Brain Injury instrument; SF-36 Physical Functioning subscale. Higher = better)												
2	observational studies	very serious[e]	not serious	serious[n]	serious[d]	none	51	37	-	SMD **0.61 SD higher** (0.18 higher to 1.05 higher)	⊕◯◯◯ Very low	IMPORTANT
Cardiorespiratory fitness - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	IMPORTANT

CI: confidence interval; **MD:** mean difference; **SMD:** standardised mean difference

Explanations

a. Downgraded one level due to high risk of bias for both studies due to allocation sequence not being concealed, and some concerns over unblinded participants and therapists, unblinded assessors (Blake 2009 only), missing data (Hei Fen 2020 only) and reporting bias.

b. Downgraded two levels due to a I2 value of 73%, and variable point estimates (1 positive and 1 negative).

c. Downgraded one level due to Hei Fen et al. (2020) having only 3/32 participants classified as msTBI in the intervention group, and only 5/32 were msTBI in the usual care group. In Blake et al. (2009), only 13/20 participants were msTBI.

d. Downgraded one level due to small sample sizes and wide confidence intervals.

e. Downgraded two levels due to being a non-randomised study of intervention and demonstrating a serious risk of bias in measurement of outcome and potential confounding, and a moderate risk of bias due to missing data.

f. Downgraded one level due to only 8 of 34 participants enrolled in the Intervention group (Physical Activity and Sport for Acquired Brain Injury) being TBI participants, while only 4 of 28 participants enrolled in the Control group (standard rehab) were TBI participants.

g. Downgraded one level due to small sample size.

h. Downgraded one level due to high risk of bias for due to allocation sequence not being concealed, and some concerns over unblinded participants and therapists, missing data and reporting bias.

i. Downgraded one level due to only 3/32 participants were msTBI in intervention group, and only 5/32 were msTBI in the usual care group.

j. Downgraded one level due to small sample sizes and confidence intervals crossing the midline suggestive of uncertainty of effect.

k. Downgraded two levels due to being a non-randomised study of intervention and demonstrating a serious risk of bias in measurement of outcome, selective reporting and potential confounding, and a moderate risk of bias due to missing data.

l. Allocation sequence not concealed, unblinded participants and therapists, no clear indication an appropriate analysis to estimate effect of the intervention was used, some concerns over potential reporting bias.

m. Population of 18 people with TBI, including people with mild, moderate and severe TBI, though unclear what the particular breakdown was. The MOS SF-36 measures perceived health status, and while a commonly used measure of quality of life, a combined overall score for quality of life is not possible (instead, subscales and summary scales are provided).

n. Downgraded one level due to only 8 of 34 participants enrolled in the Intervention group (Physical Activity and Sport for Acquired Brain Injury) being TBI participants, while only 4 of 28 participants enrolled in the Control group (standard rehab) were TBI participants in one study. In the other study, 11 of the 14 participants were msTBI in the Intervention group, while 7 of the 11 participants in the Control group were msTBI, and 5 of the total participants were not TBI at all.

FOREST PLOTS AND RISK OF BIAS ASSESSMENT

Outcome: Social connection

No studies have measured this outcome.

Outcome: Participation

No studies have measured this outcome.

Outcome: Mood

Mood at end of intervention: (sport and physical recreation vs. no intervention or non-active control)

Risk of bias (ROB-2)

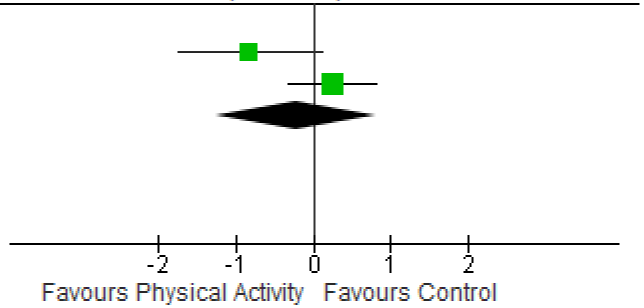
	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Blake 2009	+	-	-	-	?	+	?	+
Hwang 2020	+	-	-	+	?	?	?	+

Forest plot: Change scores: Center for Epidemiologic Studies Depression scale (1 RCT); The General Health Questionnaire (1 RCT).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
4.1.1 Change scores								
Blake 2009	-1.5	0.49	10	-1	0.67	10	43.7%	-0.82 [-1.74, 0.10]
Hwang 2020	-1.5	7	23	-3.5	8.8	28	56.3%	0.24 [-0.31, 0.80]
Subtotal (95% CI)			**33**			**38**	**100.0%**	**-0.22 [-1.25, 0.81]**

Heterogeneity: Tau² = 0.41; Chi² = 3.74, df = 1 (P = 0.05); I² = 73%
Test for overall effect: Z = 0.42 (P = 0.68)

Std. Mean Difference IV, Random, 95% CI



Mood at end of intervention: (sport and physical recreation vs. no intervention)

Risk of bias (ROBINS-I)

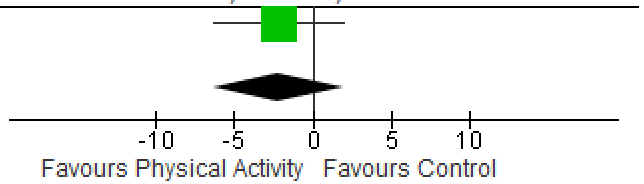
	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
Perez-Rodrigues 2021	-	+	+	+	?	-	+	-

Forest plot: Change scores: Beck Depression Inventory II (1 NRSI).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Perez Rodriguez 2021	9.53	7.89	39	11.71	9.15	28	100.0%	-2.18 [-6.38, 2.02]
Total (95% CI)			**39**			**28**	**100.0%**	**-2.18 [-6.38, 2.02]**

Heterogeneity: Not applicable
Test for overall effect: Z = 1.02 (P = 0.31)

Mean Difference IV, Random, 95% CI



Mood at end of follow-up: (sport and physical recreation vs. no intervention or non-active control)

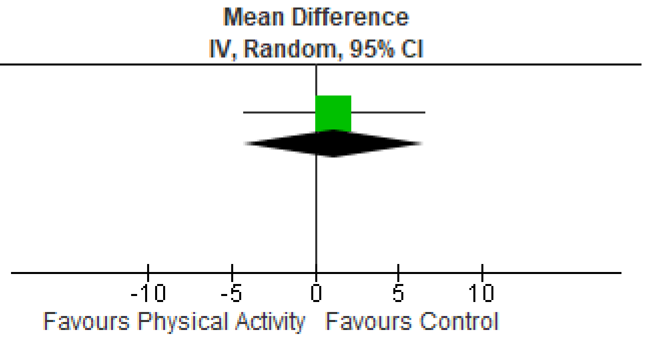
Risk of bias (ROB-2)

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Hwang 2020	+	-	-	+	?	?	?	+

Forest plot: Change scores: Center for Epidemiologic Studies Depression scale (1 RCT).

	Experimental			Control				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
4.3.1 Change scores								
Hwang 2020	-2.2	9.5	22	-3.3	10.1	29	100.0%	1.10 [-4.31, 6.51]
Subtotal (95% CI)			**22**			**29**	**100.0%**	**1.10 [-4.31, 6.51]**

Heterogeneity: Not applicable
Test for overall effect: Z = 0.40 (P = 0.69)



Outcome: Physical activity

Physical activity at end of intervention: (sport and physical recreation vs. no intervention)

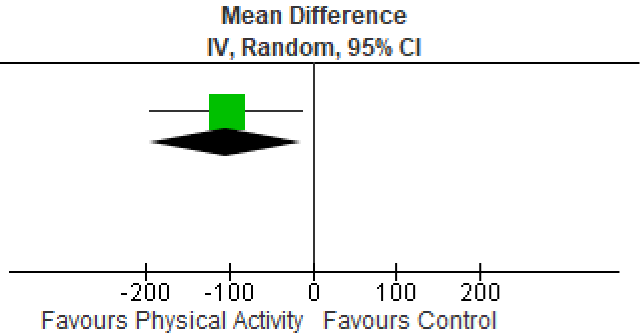
Risk of bias (ROBINS-I)

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias

Perez-Rodrigues 2021	-	+	+	+	?	-	+	-

Forest plot: Time in sedentary behaviour measured with the Global Physical Activity Questionnaire (1 NRSI).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
4.4.2 NRSI End of Intervention								
Perez Rodriguez 2021	651.4	186.25	34	755.4	179.31	28	100.0%	-104.00 [-195.27, -12.73]
Subtotal (95% CI)			**34**			**28**	**100.0%**	**-104.00 [-195.27, -12.73]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.23 (P = 0.03)								



Outcome: Comorbidities and mortality

No studies have measured this outcome.

Outcome: Quality of life

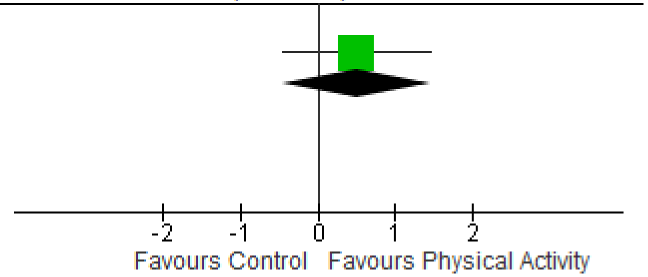
Quality of life at end of intervention (sport and physical recreation vs. no intervention)

Risk of bias (ROB-2)

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Gemmell 2006	+	-	-	+	?	+	?	+

Forest plot: SF-36 Physical Health summary scale (1 NRSI).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
4.5.1 End of intervention								
Gemmell 2006	236.36	94.59	9	191.53	73.93	9	100.0%	0.50 [-0.44, 1.45]
Subtotal (95% CI)			**9**			**9**	**100.0%**	**0.50 [-0.44, 1.45]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.05 (P = 0.30)								



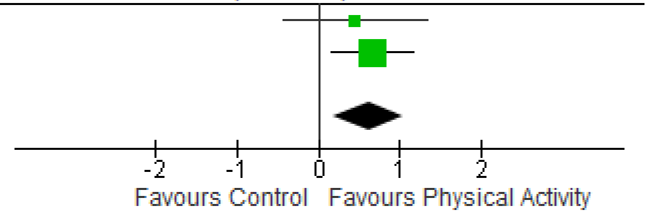
Quality of life at end of intervention (sport and physical recreation vs. no intervention or non-active control)

Risk of bias (ROBINS-I)

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
Donnelly 2017	-	+	+	+	?	-	+	-
Perez-Rodrigues 2021	-	+	+	+	?	-	+	-

Forest plot: Adapted version of the Quality-of-Life After Brain Injury instrument (1 NRSI); SF-36 Physical Functioning subscale (1 NRSI).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Donnelly 2017	2.15	0.34	12	1.96	0.48	9	24.5%	0.45 [-0.43, 1.33]
Perez Rodriguez 2021	72.65	19.32	39	58.93	21.7	28	75.5%	0.67 [0.17, 1.17]
Total (95% CI)			**51**			**37**	**100.0%**	**0.61 [0.18, 1.05]**
Heterogeneity: Tau² = 0.00; Chi² = 0.18, df = 1 (P = 0.67); I² = 0%								
Test for overall effect: Z = 2.77 (P = 0.006)								



Outcome: Cardiorespiratory fitness

No studies have measured this outcome.

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Clinical question 8: Sport and physical recreation for children and adolescents with moderate to severe traumatic brain injury

Clinical question

Should **sport and physical recreation** compared to control be used for **children and adolescents** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home
- Schools

Perspective: Health systems

Outcomes of interest:

1.	Social connection	CRITICAL
2.	Participation	CRITICAL
3.	Mood	CRITICAL
4.	Physical activity	IMPORTANT
5.	Co-morbidities and mortality	IMPORTANT
6.	Quality of life	IMPORTANT
7.	Cardiorespiratory fitness	IMPORTANT

Conditional recommendation:

For children and adolescents after moderate to severe TBI, we suggest participation in sport[4] and physical recreation[5] across the continuum of care considering their personal preference and capability.

Good Practice Points:

[4] "an activity involving physical exertion, skill and/or hand-eye coordination as the primary focus of the activity, with elements of competition where rules and patterns of behaviour governing the activity exist formally through organisations" (ABS, 2008).

[5] "an activity or experience that involves varying levels of physical exertion, prowess and/or skill, which may not be the main focus of the activity and is voluntarily engaged in by an individual in leisure time for the purpose of mental and/or physical satisfaction" (ABS, 2008).

We suggest:

- Health professionals consider what sport and/or physical recreation the child or adolescent enjoyed and participated in prior to their brain injury when developing their rehabilitation program. Pre-injury activities may be a facilitator or may cause distress if physical, cognitive, or behavioural impairments restrict participation.
- Health professionals consider all aspects of the inclusion spectrum[6] when suggesting options for sport and/or physical recreation.
- Health professionals establish relationships and work with external service providers to facilitate access and opportunities for their clients to participate in sport and/or physical recreation.
- Health professionals support the child or adolescent and their family to facilitate participation in sport and/or recreation, including supporting preparation of funding requests, and identifying modifications, support and adaptive or specialised equipment necessary to ensure the safety and appropriateness of the activity.

Precautionary Point:

- A knock to the head from sport participation may cause a second brain injury. Risk vs. benefit should be considered and discussed by the interdisciplinary team and advice provided to the child or adolescent and their family.

[6] The inclusion spectrum is about viewing inclusion in sport and physical recreation activities along a spectrum. A version of the Inclusion Spectrum was devised by the Australian sports Commission (ASC). It includes no modifications, minor modifications, major modifications, primarily for people with disability, only for people with disability.

Justification

Overall justification

Physical inactivity is highly prevalent and problematic for children and adolescents after msTBI. Sport and physical recreation programs can provide opportunities for children and adolescents to engage in physical activity in a social and supportive environment.

Detailed justification

Problem

Children and adolescents after msTBI have high levels of physical inactivity, which can have negative consequences, including physical deconditioning, compromised aerobic capacity, and functional impairment, and can lead to chronic health conditions later in life.

Desirable Effects

The World Health Organisation (WHO) guidelines strongly recommend for children and adolescents living with disability to do at least an average of 60 minutes per day of moderate to vigorous intensity, mostly aerobic, physical activity, across the week.

Balance of effects

Trivial or small undesirable effects and potentially moderate effects on critical and important outcomes.

Acceptability

Good acceptability from multiple stakeholders.

Feasibility

Feasible to deliver in inpatient and post-rehabilitation settings, although implementation support will be needed, especially for services and clinicians working with children and adolescents with higher support needs.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**	Varies	Don't know	
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large	Varies	Don't know	
UNDESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large	Varies	Don't know	
CERTAINTY OF EVIDENCE	Very low	Low	Moderate	High	No included studies		
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	**Varies**	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High	**No included studies**		
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	**Probably yes**	Yes	Varies	Don't know	
FEASIBILITY	No	Probably no	**Probably yes**	Yes	Varies	Don't know	

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

PROBLEM Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	• Physical activity is associated with a 20%–30% lower risk in all-cause mortality and incidence of multiple chronic conditions (McKinney et al., 2016). The benefits of physical activity for children and adolescents are wide-ranging and well documented (Biddle et al., 2004) • Children and adolescents aged 5–17 years should accumulate at least 60 minutes per day of moderate-to-vigorous-intensity physical activity, on average, and incorporate vigorous-intensity aerobic activities as well as muscle- and bone-strengthening activities at least three days per week (WHO, 2020). • Globally, children and adolescents have low levels of physical activity (Aubert et al., 2022). Children and adolescents with msTBI are even less physically active than their non-brain injured peers (Katz-Leurer et al., 2010). • Low levels of physical activity can have negative consequences after msTBI, including physical deconditioning, compromised aerobic capacity, and functional impairment, and can lead to chronic health conditions later in life (Hamel et al., 2019).	Sport is "an activity involving physical exertion, skill and/or hand-eye coordination as the primary focus of the activity, with elements of competition where rules and patterns of behaviour governing the activity exist formally through organisations" (ABS, 2008). Physical recreation is "an activity or experience that involves varying levels of physical exertion, prowess and/or skill, which may not be the main focus of the activity and is voluntarily engaged in by an individual in leisure time for the purpose of mental and/or physical satisfaction" (ABS, 2008).

DESIRABLE EFFECTS How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	There is no evidence to guide this judgement in children and adolescents in TBI research. **Evidence in adults with TBI:** Sport and physical recreation had variable effect on mood, with there being a slight indication that sport and physical recreation can improve mood in adults after msTBI. Though there was no clear long-term effect of the intervention on mood. A sport and physical recreation intervention may reduce time spent sedentary and quality of life, through the evidence is limited and has a very low degree of certainty. **Evidence from WHO physical activity guidelines for disability (Carty et al., 2021):** • WHO guideline development group considered the evidence for children without disability could be extrapolated for children living with disability for key outcomes including favourable outcomes on cardiorespiratory and muscular fitness,	Nil.

	cardiometabolic health, bone health, cognitive outcomes, mental health, and adiposity. • WHO guideline development group considered evidence for physical activity for children living with intellectual disability and children with attention deficit hyperactivity disorder (ADHD). They found low-certainty evidence of improved physical function in children with intellectual disability and moderate-certainty evidence that moderate to vigorous physical activity can have beneficial effects on cognition, including attention, executive function, and social disorders in children with ADHD. The WHO guidelines recommend for children and adolescents (aged 5–17) living with disability it is recommended that: • Children and adolescents living with disability should do at least an average of 60 minutes per day of moderate to vigorous intensity, mostly aerobic, physical activity, across the week. *Strong recommendation, moderate certainty evidence* • Vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone should be incorporated at least three days a week. *Strong recommendation, moderate certainty evidence*	
UNDESIRABLE EFFECTS How substantial are the undesirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
● Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know	There is no evidence to guide this judgement in children and adolescents in TBI research. **Evidence from adults with TBI:** No negative effects found on any of the critical or important outcomes. Adverse events (AEs) were not explicitly mentioned in all studies. No serious adverse events (SAEs) were reported in any study. **Evidence from WHO physical activity guidelines for disability (Carty et al., 2021):** The WHO guidelines suggest the following Good Practice Point for children and adolescents (aged 5–17) living with disability: • There are no major risks for children and adolescents living with disability engaging in physical activity when it is appropriate to an individual's current activity level,	**Clinical expertise input:** Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken. **Cochrane review on exercise interventions in cerebral palsy (Ryan et al., 2017):** Thirteen trials did not report AEs, seven reported no AEs, and nine reported non-serious AEs.

	health status and physical function; and the health benefits accrued outweigh the risks.	

CERTAINTY OF EVIDENCE

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ○ Moderate ○ High ● No included studies	There is no evidence to guide this judgement in children and adolescents in TBI research. **Evidence from adults with TBI:** All outcomes evaluated were rated as very low certainty evidence.	Nil.

VALUES

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted in TBI to inform the value children and adolescents after msTBI place on the main outcomes. **BRIDGES qualitative research with people living with TBI:** The challenge of physical activity could undermine an individual with TBI's confidence by highlighting their disability and limitations, which can have significant psychological impacts: *"Prior brain injury I loved sport, I could run, I could play many sports well. I used to love physical activity. After my injury I could not do it, I was good at basketball, hence I tried wheelchair basketball but failed miserably at that…. even after knowing previously the rules it would become overwhelming and I failed…. It's hard enough trying to accept your disability and … that just crushed me."* (P15) "*[I] want to be a better dancer, have straighter legs, because with me, being a kid with an ABI, a lot of my life I've noticed that looking in the mirror and me having a difference in the shortage of my legs and my arms not being perfect like others, it's made me think, should I really be alive? Should I be living and doing all that stuff that I love?*" (P14)	If sport and physical recreation can enable the child or adolescent to participate in activities with their peers, it is likely to be of value to them.

	BRIDGES qualitative research with stakeholder groups: Sport and physical recreation in the community that requires the family to drive the activity may be challenging for them to prioritise, particularly if there are other children and activities to juggle. *".... so a person who has mobility issues, the day starts getting out of bed, getting into a chair, or getting ready, getting down the ramp into their house, into their car, driving to wherever they need to go, finding parking. If they need a high ab or something like that to transfer between wheelchairs, their car wheelchair to a beach wheelchair, getting down onto the beach in soft sand, getting into the water, and then the surf might not be cooperating that day and it might be quite dangerous to put somebody in the water, and then participating and then doing all the reverse of that to go home."* (Exercise provider) *"families have got other priorities. So if you gave them that [WHO guideline recommendations] as the guideline, there's no way that they would say that that's something that they would be able to meet, particularly early on in their journey of traumatic brain injury. Maybe many, many years down the track, but definitely not early on."* (Health Professional) *"the ones that have succeeded are the ones where the client is motivated and you can find something really meaningful, salient to that individual. And often they come with that background and then they've got the family who are on board and are able to succeed. And it can be amazing, competitive, high-level athletics, or it can just be these families that they go fishing and they go kayaking and they're doing stuff all the time that's physical, even though it's not at a competitive or athletic level. And I think there's a lot of the children, a lot of family drive as well."* (Health Professional)	

BALANCE OF EFFECTS

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	Trivial or small undesirable effects and variable desirable effects including potentially moderate effects on critical and important outcomes.	Nil.

RESOURCES REQUIRED How large are the resource requirements (costs)?"		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies ○ Don't know	Cost data is not available from any studies in TBI. The cost of the required resources likely varies depending on the needs of the person with TBI, e.g., if they can independently participate in sport and physical recreation, or if they need one-on-one supervision or specific equipment to facilitate their participation in the activity. **BRIDGES audit of brain injury services:** Six paediatric services across Australia (Location: 3/8 states and territories; all in major cities; 5 public, 1 private; 4 specialist inpatient brain injury rehabilitation, 1 inpatient rehabilitation service that manages some brain injury clients, 1 private practice). Number of sites who have the following equipment for sport and physical recreation in inpatient and/or outpatient services: Sporting equipment (including balls, bats, hoops, goals, hurdles) (4/6; 66%), facilities (e.g., running track, courts, nearby park) (2/6; 33%), adaptive wheelchairs/bikes (2/6; 33%). **BRIDGES qualitative research with stakeholder groups:** It was noted from multiple stakeholders the need for attendant care workers to support participation in physical activity (including sport and physical recreation) including supporting travel, motivation to do the activity, supervision of home or gym programs. *"I find one of the biggest barriers is if they're wanting to get back to community sport or engage in regular exercise that they may have been participating in prior to their injury and are really motivated to get back to that, some of the barriers around access and appropriate equipment, support to be able to get them there, often they're not driving. I think those things become quite difficult, so it's probably more so around appropriate equipment, access and support for transport."* (Health Professional) It was noted from health professionals and community physical activity providers, that specialised/adapted equipment is needed for those with higher support needs that either needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment. *"There's a whole range of things, like hand cycling and recumbent bikes are a big passion of mine, so I love adapted bikes, that that's a great way to get people engaged, and that's just on a recreational level, and then we've got that cohort that want to go that little bit further and get classified, and then try to go onto the Paralympics or compete, so cool."* (Health Professional)	**BRIDGES audit of brain injury services:** 26 services across Australia (Location: 8/8 states and territories; 22 major cities, 2 regional, 2 outer regional or remote; 19 public, 3 private, 4 mixed services; 12 specialist brain injury services with inpatient service, 6 private practices that work with TBI clients, 4 inpatient rehabilitation services that manage some brain injury clients, 2 outpatient community rehabilitation teams, 1 specialist brain injury services transition/case management, 1 acute neurosurgical ward; Client type: 6 services children and adolescents, 21 working age adults, 14 older adults).

CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES What is the certainty of the evidence of resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies include cost data about the resources required.	Nil.

COST EFFECTIVENESS Does the cost-effectiveness of the intervention favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Nil.

EQUITY What would be the impact on health equity?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	• General population studies have shown lower physical activity levels in lower socioeconomic areas (Jerome et al., 2023). Providing access and opportunities for children and adolescents after msTBI to participate in sport and physical recreation will likely benefit those in more disadvantaged groups. • Access to inpatient rehabilitation services is within public health system, so access for all is dependent on need, not funding. • There is likely access to state-based funding and NDIS for any with moderate to severe injury (if meet inclusion criteria) to support sport and physical recreation post inpatient rehabilitation, but completion of forms etc. for access to these	Nil.

	funding schemes may be more challenging for those with lower socioeconomic backgrounds or less family support. • National guidelines may support providers to deliver and funders to fund sport and physical recreation for those living in more regional, rural and remote areas that aren't as linked in with specialist brain injury services.	
ACCEPTABILITY Is the intervention acceptable to key stakeholders?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Looking more closely at paediatric services, 5 of the 6 sites (83%) provided sport and physical recreation, which was delivered by physiotherapists (5/6; 83%), allied health assistants (2/6; 33%), exercise physiologists (1/6; 16%), sport and recreation officers (1/6; 16%), occupational therapists (1/6; 16%), and external sport providers (1/6; 16%). **BRIDGES qualitative research with stakeholder groups:** In relation to acceptability of the WHO guideline level of physical activity (60-min per day moderate to vigorous physical activity), all stakeholder groups were overall accepting of this but identified that some with more severe injuries (cognitive, behavioural and/or physical impairments) may not be able to meet this level (intensity and/or duration) or may need additional support/equipment and time to achieve this. *"I think with the right person, the right attitude, the right help, they* (the WHO physical activity guidelines) *could be reached."* (Family member) *"... families have got other priorities. So if you gave them that as the guideline, there's no way that they would say that that's something that they would be able to meet, particularly early on in their journey of traumatic brain injury. Maybe many, many years down the track, but definitely not early on."* (Health Professional) It was suggested resources that provide examples of how a range of different people with msTBI meet these levels (and how to define moderate intensity activity) would be useful. It was also noted that the good practice points of the WHO guideline were very important. *"I would discuss being physically active on every day, pick and choose elements of that. I wouldn't rarely talk about the number of minutes or intensity at the stage with most of my*	Sport and physical recreation are physical activities suitable for people of all ages and abilities (WHO, 2018). Sport and physical recreation can be modified or use equipment to enable the participation of people with disabilities in either mainstream or disability-specific activities (Kiuppis et al., 2018). The inclusion spectrum includes options for participation in sport and recreation (Kiuppis et al., 2018): *(1) Separate Activity:* Special activities, specially thought for and proposed for people with disability and practised in different times and spaces. *(2) Parallel Activity:* Disabled athletes may need to train separately with disabled peers to prepare for a competition, such as a wheelchair basketball group included in a local basketball club. *(3) Disability Sport Activity:* Reverse integration whereby non-disabled children and adults are included in disability sport together with disabled peers. *(4) Open (inclusive) Activity:* Everyone does the same activity with minimal or no adaptations to the environment or equipment; open activities are by their nature inclusive so that the activity suits every participant. *(5) Modified Activity:* Activities designed for all, with specific adaptations to space, tasks, equipment and people's teaching.

	clients, but sitting less, moving more, those types of more general principles. Similarly to the second page, I might use something that's more like that. Yeah."(Health Professional)	
FEASIBILITY Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Sport and physical recreation appears feasible in rehabilitation settings when delivered or supervised by health professionals. Of the six paediatric services that participated in the audit, 5 of the 6 services (83%) indicated they linked their clients to an external provider for sport and physical recreation training. Most commonly this was to a disability specific sporting organisation (3/6; 50%). Several barriers to delivering sport and physical recreation to children and adolescents after msTBI were identified, including a lack of resources (6/6; 100%), knowledge (4/6; 66%), and time (3/6; 50%). **BRIDGES qualitative research with stakeholder groups:** The delivery of sport and physical recreation in community settings may require specific resources (e.g., equipment, staff) and appropriate opportunities (e.g., inclusive or disability specific facilities and programs). Funding from state-based funders or NDIS may support this, however it would need to meet legislative requirements, fit within participant-developed goal and require submission of paperwork. *"the NDIS will fund modified recreational activities including equipment, but you need to clearly show that again it's reasonable and necessary and that what you're asking to do is not something like if you ask just to buy an e-bike, it has to be clearly linked to the fact that it's linked to your disability and what you're on the scheme for.*" (Service funder) Opportunities to participate in sport and physical recreation are likely to arise in the school setting. There needs to be a willingness of schools to engage with outside providers (e.g., health professionals) and to see the importance of sport and physical recreation participation as part of the education curriculum for children and adolescents living with disabilities such as TBI. *"One of the facilitators can be the schooling environment. If you've got the right people in the schooling environment that can help promote physical activity in a way that is enjoyable, successful, meaningful, then that means their participation in those areas can be positively*	Nil.

	influenced, rather than them sitting out on things or timekeeping or keeping score, any of those terrible things." (Health Professional)	

SUMMARY OF FINDINGS TABLE, FOREST PLOTS AND RISK OF BIAS ASSESSMENT

No studies measured any of the critical or important outcomes identified for this intervention. Therefore, no summary of findings tables, forest plots or risk of bias were completed for this clinical question.

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Clinical question 9: Overall physical activity promotion for adults and older adults with moderate to severe traumatic brain injury

Clinical question

Should **overall physical activity promotion** compared to control be used for **adults and older adults** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home

Perspective: Health systems

Outcomes of interest:

1.	Physical activity	CRITICAL
2.	Social connection	CRITICAL
3.	Behaviour change	CRITICAL
4.	Quality of life	CRITICAL
5.	Co-morbidities and mortality	CRITICAL
6.	Participation	CRITICAL
7.	Mood	CRITICAL

Conditional recommendation:

For adults and older adults after moderate to severe TBI, we suggest the promotion of physical activity across the continuum of care.

Good Practice Points:

We suggest:

- Physical activity is promoted with consideration of current public health physical activity guideline recommendations for adults and older adults living with disability.

- Health professionals initiate conversations with clients about a return to physical activity as early as possible, mindful of the potential for the early rehabilitation phase of recovery to be an opportune time to establish short and long-term goals, positive behaviours, and support systems.
- Pre-injury physical activity is assessed, and health professionals consider building on what the adult has done before (i.e., supporting a return to previous activity).
- Key aspects of the promotion of overall physical activity include exploring the clients understanding of the benefits of physical activity, identification of goals, utilising evidence-based behaviour change techniques to support self-management, and implementing activities that broadly encourage physical activity.
- Health professionals seek to identify barriers to engaging in physical activity and implement strategies to support the uptake of physical activity.
- Physical activity is incorporated into weekly routines and key supports (e.g., family, friends, and support workers) are trained in facilitating opportunities for activity where appropriate.

Justification

Overall justification

Adults and older adults after msTBI are typically physically inactive. The promotion of overall physical activity to adults and older adults after msTBI may increase their physical activity levels and participation.

Detailed justification

Problem

Physical inactivity is a critical problem leading to health complications secondary to brain injury and premature death. Adults living with disability from TBI face multiple barriers to being physically active and may benefit from assistance from health professionals to overcome these barriers.

Certainty of evidence

The certainty of evidence is low.

Balance of effects

On the balance of effects, interventions that promote overall physical activity are probably favoured.

Equity

The promotion of overall physical activity probably increases equity by benefiting underserved populations and empowering disadvantaged populations.

Feasibility

Promotion of physical activity within rehabilitation is feasible and needed to support adults with TBI to overcome barriers and navigate suitable and preferable community-based physical activity options.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	Very low	**Low**	Moderate	High		No included studies	
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	**Negligible costs and savings**	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High		No included studies	
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	No included studies
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	A USA-based cohort study with 472 participants found that 55% of adults after msTBI did not meet physical activity guidelines, and this was worse for adults aged 45+ years (68%) (Pham et al., 2022). In a cohort of 160 people with msTBI, >80% of study participants had not returned to pre-injury leisure participation at 12-months post-injury, with pre-injury physical activity participation replaced by sedentary activity (i.e., watching television) (Wise et al., 2010). In a systematic review intended to identify predictors of physical activity post-TBI, Hamilton et al. (2017) reported the physical activity levels of the TBI participants in the six studies included in the review were below that required for general health maintenance. Supporting adults after msTBI to identify and engage in activities that increase overall physical activity, and reduce time spent inactive, is critical to avoiding secondary complications and preventing the health risks associated with physical inactivity.	Nil.
Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**

○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	**Evidence from TBI:** Two randomised controlled trials (RCTs) (Brenner et al., 2012; Driver et al., 2023), one cross-over RCT (Bellon et al., 2015; Kolakowsky-Hayner et al., 2017 - two articles from the same study), and two NRSIs (Clanchy 2016; Driver 2016) reported on the effects of interventions characterised as activities that can increase overall participation in physical activity by adults after msTBI. Of the seven outcomes identified as critical or important, two (i.e., social connection and quality of life) were not measured, while behaviour change and composite mobility were measured, but the data was not reported for these outcomes. The lack of reported data and overlap in the included studies outcomes limit the opportunity to use meta-analytical techniques to interrogate the data and clouds the judgement on the desirability of the anticipated effects of overall physical activity promotion. Overall physical activity had a positive effect on levels of physical activity. For two non-randomised studies of interventions (NRSIs), we pooled the immediate effect of the intervention on physical activity data (device-based measure of time in moderate-vigorous physical activity in mins/day (Clanchy et al., 2016) and self-reported mins/week (Driver et al., 2016). The meta-analysis indicated the intervention had a large positive effect on physical activity (two studies, 90 participants; SMD= 2.66; 95% CI 1.18 to 4.15; I2=84%; very low certainty evidence). The effect was maintained (though marginally reduced) at end of follow-up (two studies, 90 participants; SMD= 1.37; 95% CI 0.28 to 2.46; I2=81%; very low certainty evidence). Clanchy et al. (2016) report on a NRSI in which a 12-week physical activity intervention (stage-matched behaviour change activities, exercise prescription, community access facilitation and relapse prevention strategies) is compared to a non-active control in 43 adults with acquired brain injury, including 21 people with TBI. The intervention effectively increased adoption of physical activity (time in moderate-to-vigorous physical activity: MD 13 min/day, 95% CI 1 to 25), but it was not maintained at follow-up. While Driver et al. (2016) reported on a quasi-experimental trial in which 47 people with brain injury (19 TBI, 28 stroke) in a transitional outpatient setting were consecutively enrolled into an 8-week informational, social, and behavioural program aimed at facilitating increased activity for 6-months or a usual care control group (following 6-months). The intervention effectively increased the amount of time in moderate-to-vigorous physical activity more than control group (time in moderate-to-vigorous physical activity: MD 24 min/week, 95% CI 17 to 31), and this difference was maintained at follow up (time in moderate-to-vigorous physical activity: MD 23 min/week, 95% CI 17 to 30). In Driver et al. (2023), 54 people with msTBI were randomised to a 12-month Diabetes Prevention Program Group Lifestyle Balance for TBI (GLB-TBI) (a weight-loss intervention) or an attention control group. Using blood pressure as a proxy measure for comorbidities and	Physical activity counselling interventions that are underpinned by theoretical models of behaviour change and incorporate behaviour change techniques including identifying barriers, self-monitoring, goal setting and feedback have been shown to increase physical activity in the general population (Michie et al., 2009) as well as people with physical disabilities (van der Ploeg et al., 2007). The World Health Organization's Global Action Plan on Physical Activity 2018–2030 supports the promotion of physical activity within health services as one of its 20 policy actions to achieve a 15% relative reduction in the global prevalence of physical inactivity by 2030 (WHO, 2018).

	mortality, there was no clear effect of the intention on systolic blood pressure (one study, 47 participants; MD= -1.20; 95% CI -9.73 to 7.33; moderate certainty evidence). Bellon et al. (2015) and Kolakowsky-Hayner et al. (2017) report on a cross-over RCT (n=123), randomised to a 12-week home-based walking programme or a nutrition coaching control group. Bellon et al. (2015) reported on 69 participants with TBI, including 45 with moderate or severe TBI. There was no clear effect of the intervention on mood at end of intervention (one study, 67 participants; MD= -3.11; 95% CI -8.11 to 1.89; very low certainty evidence). While Kolakowsky-Hayner et al. (2017), reported an increase in physical activity, as measured by step counts, but there was no difference between the walking and control groups (mean increase across the two groups = 1857 daily steps [+29.5%]). An overall physical activity promotion intervention also had a positive effect on participation. In the Driver et al., (2016) NRSI, there was a small positive effect of the intervention on participation at end of intervention (one study, 47 participants; MD= -4.49; 95% CI -8.56 to -0.42; very low certainty evidence) and end of follow-up (one study, 47 participants; MD= -5.70; 95% CI -9.36 to -2.02; very low certainty evidence). **Evidence from stroke:** Morris et al. (2014) conducted a systematic review to investigate the long-term (i.e., >3-months) effects of interventions targeting the promotion of physical activity for community-dwelling people with stroke. Eleven (n = 11) RCTs or comparison studies, including 1,704 people with stroke, were included in the review, with two broad types of intervention identified: individualized tailored counselling with or without supervised exercise (n = 6 studies) and supervised exercise with advice (n = 5 studies). In three studies, a tailored counselling intervention increased the odds of meeting recommended physical activity levels and participation in physical activity at 12-months post-intervention; while in one study, supervised exercise improved step counts at 3-months follow-up, despite there being no change in self-reported physical activity. Tailored home exercise was the only predominantly exercise-based intervention to demonstrate higher physical activity participation at 12-months.	

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS

○ Trivial ● Small ○ Moderate ○ Large ○ Varies ○ Don't know	**Evidence from TBI:** No negative effects found on any of the critical or important outcomes. There were no serious adverse events (SAEs) or adverse events (AEs) reported in two of the three RCTs described above (Bellon et al., 2015 and Kolakowsky-Hayner et al., 2017; Brenner et al., 2012). Driver et al. (2023) reported seven SAEs occurred in their study, including surgeries (n = 2), a fall (n = 1), a seizure (n = 1), an infection (n = 1), stroke-likely symptoms (n = 1), and one participant endorsed suicidal ideation without a plan or intention. All SAEs were unrelated to the study protocol, as were the 17 AEs that were also recorded (i.e., seizures, n = 4; COVID-19 infections, n = 4; fainting/falls, n = 3; upper limb pain, n = 2; dehydration, n = 1; kidney stone, n = 1; elevated blood pressure, n = 1; abdominal pain, n = 1). Of the aforementioned NRSI, none specifically reported on the incidence of AEs or SAEs in their studies. **Evidence from stroke:** People with stroke experience very few adverse events in physical fitness interventions (i.e., aerobic exercise, muscle strengthening) (Saunders et al., 2020). **Evidence from WHO physical activity guidelines for disability (Carty et al., 2021):** The WHO guidelines suggest the following Good Practice Point for adults and older adults living with disability: There are no major risks to adults living with disability engaging in physical activity when it is appropriate to the individual's current activity level, health status, and physical function; and when the health benefits accrued outweigh the risks.	**Clinical expertise input:** Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken. Risk of musculoskeletal injuries as a result of participating in sport and/or physical recreation likely no different to the risk posed to those without TBI.

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ● Low ○ Moderate ○ High ○ No included studies	See the Summary of Findings table.	Nil.

Values Is there important uncertainty about or variability in how much people value the main outcomes?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted in TBI to inform the value adults after msTBI place on the main outcomes. **BRIDGES qualitative research with people living with TBI:** As part of the BRIDGES project, we conducted focus groups and think aloud focus groups to design a discrete choice experiment (DCE) to learn about preferences for community-based physical activity. The DCE survey remains an ongoing study, but synthesis of qualitative data from focus groups indicates the important role participating in overall physical activity has in the recovery from a msTBI. As a common symptom of TBI, fatigue was described as a potential barrier to physical activity by nearly all participants, even though they recognised the paradox of improving their overall fatigue through tiring physical activity: *"I was lying in a hospital bed for six weeks … then there was muscle wastage for the next 18 months as I tried to recover. So, I didn't have any strength to do anything, which meant I was always fatigued. I feel if you can improve people's strength and fitness, then they can cope with everyday tasks better. That gives them more energy. Therefore, they're less fatigued…. people don't seem to understand that to alleviate that fatigue, you have to work hard, which makes you more fatigued, but in the long run, you become less fatigued. That's the perception I'd like to change."* (P3) For many, the physiological and cognitive challenges associated with new activities, or heightened physical activity, could be overwhelming and needed to be managed carefully or avoided: *"… you've got this inner limitation that you can't control those symptoms, and for me, there are things like dizziness, loss of balance, vomiting, nausea,… extreme exhaustion, my vision starts going, can't think... It's almost like a nasty cycle. I've tried to not go there … because I've learnt pushing through takes me to that place that isn't enabling my body to improve."* (P1) There is also the impact the challenge of physical activity might have on the individual's confidence and self-esteem, and how the activity might highlight their disability: *"Prior brain injury I loved sport, I could run, I could play many sports well. I used to love physical activity. After my injury I could not do it, I was good at basketball, hence I tried wheelchair*	Nil.

	basketball but failed miserably at that.... even after knowing previously the rules it would become overwhelming and I failed.... It's hard enough trying to accept your disability and ... that just crushed me." (P15) Many felt they would benefit from greater social interaction and saw physical activities as a good place for this, to the extent that it could be a deciding factor in choosing to try a new activity: *"You're really isolated when you've had a brain injury, because everything stops what you would normally go and do. So, you do spend quite a lot of time just at home and your four walls can get quite closed in. So, any opportunity to go out, and do something, and to interact with other people, and to get out of your own head for even five minutes, I would jump at with both hands and feet."* (P2) *"... for me too, it was a way of connecting, particularly looking for team sports. I was trying to connect with people from being so isolated, being in rehab and having this injury and going from somebody that's very able bodied to being very dependent on other people. So having connections outside, I think that was a big draw card for me."* (P18) Several participants talked about the therapeutic value of connection to nature, including relationships and recreational activity with animals such as horses and dogs: *"... if you've had a long term incarceration in hospital I think being outside becomes really important to you. I might not have been outdoorsy before the accident, but after nearly a year in hospital, I was just so desperate to get outside and do stuff.... So I think as much exercise that you can do, outside is better."* (P17)	

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	There is limited evidence of undesirable effects of the intervention, with no study-related SAEs or AEs reported, and little, if any, uncertainty about the value of the outcomes to adults after msTBI. There is some evidence of the benefits of overall physical activity promotion, though the quality of the evidence is low. On the balance of desirable and undesirable effects, the promotion of overall physical activity is probably favoured over the alternative (i.e., not participating in overall physical activity promotion).	Nil.

Resources required

How large are the resource requirements (costs)?"

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	Cost data is not available from any studies in TBI. A reduction in population level physical inactivity is likely to be cost saving for health system. **BRIDGES audit of brain injury services:** Of the 21 adult Australian brain injury services audited, it was standard practice for their patient's physical activity levels to be assessed in 18 (86%) services as a part of their role in broadly promoting physical activity. For all of these services, patient observation and history taking were the primary method for assessing physical activity levels, but for three services working with community-based individuals, device's, such as heart rate monitors and smartwatches, were used to measure levels of physical activity. Though whether the devices are the patient's own, and the health practitioners are taking advantage of their patients access and familiarity with such a device, or whether the device is given to the patient by the healthy practitioner, is unclear. **BRIDGES qualitative research with people living with TBI:** Costs of physical activities, transport, and equipment and, primarily, variability in insurance coverage, played a very significant role in enabling or obstructing access to physical activity: *"I get help by the NDIS, so that is a major factor in what exercise I choose to do…. I wouldn't have an exercise physiologist … coming to my house if we weren't getting help. I can guarantee, that's a big deal…. we couldn't afford to be supporting exercise physiology and the gym and all the other stuff if we weren't getting help."* (P3) Whereas for others, especially those with higher support needs, it was essential to find an activity, often with a facilitator, that was more attuned to their needs: *"I need a personal trainer because my body is stronger than my brain. So if I didn't have the safety requirements of the personal trainer guide me through- yesterday with the leg press machine I did a hundred reps of 250 kilos and I couldn't do that on my own, because first I couldn't load up the machine with five 20 kilo plate from each side."* (P20)	Nil.

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Very low ○ Low ○ Moderate ○ High ● No included studies	Data on resource requirements not available for adults after msTBI. The promotion of overall physical activity to adults after msTBI should include assessment of physical activity levels, providing information about the benefits of physical activity and meeting activity guidelines, collaboratively setting physical activity goals, and using behaviour change techniques activity uptake and maintenance. The resources requirements to promote overall physical activity are likely to be low cost and could be covered as part of standard care for health practitioners.	Nil.

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Nil.

Equity

What would be the impact on health equity?

JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies	In the general population, people living in lower socioeconomic areas experience lower levels of physical activity (Jerome et al., 2023). Promoting overall physical activity will likely benefit those in more disadvantaged groups.	Nil.

○ Don't know	Access to inpatient rehabilitation services is within the public health system, so access to health practitioners for all adults after msTBI is dependent on need, not funding. There is access to state-based funding and the National Disability Insurance Scheme (NDIS) for any with msTBI to support engagement in formal physical activities post-inpatient rehabilitation (if <65 years of age), but completion of forms, follow-up with the funders etc. for access to these funding schemes may be more challenging for those from lower socioeconomic backgrounds, or those with English as a second language. National guidelines may support providers to deliver and funders to fund the overall promotion of physical activity for those living in more regional, rural and remote areas that aren't as linked in with specialist brain injury services.	

Acceptability

Is the intervention acceptable to key stakeholders?

JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	In a pre-post study, Jones et al. (2016) demonstrated an 8-week, remotely delivered (via email) self-management program ('myMoves') was acceptable to community-based people with an acquired brain injury (including 4 TBI). The average clinician contact time per participant during the program was only 32.8 minutes (SD= 22.8), while program acceptability was very high, with >95% (22/23) of participants being either very satisfied or satisfied with the program and stating that it was worth their time. All participants stated that they would recommend the program to others with an acquired brain injury. In a mixed-methods feasibility study, Quilico et al. (2022 [conference abstract only]) found an outdoor walking-group intervention targeting the promotion of physical activity for adults with msTBI (n = 18) was acceptable. The authors reported 15 of 18 (83%) participants completed 75% or more of the scheduled sessions, and all participants reported high satisfaction with the intervention and would recommend the walking group to others. While no SAEs were reported, there were reports of minor AEs, such as fatigue and muscle soreness. **BRIDGES audit of brain injury services:** Of the 21 adult brain injury services audited across Australia, 14 saw only working age adults, while the remaining seven saw both working age adults as well as older adults.	Nil.

	Location: 8/8 states and territories; 17 major cities, two regional and two outer regional or remote. *Type:* 14 public, three private, and four mixed brain injury services were included in the audit. These include: eight specialist brain injury services with inpatient service, six private practices that work with TBI clients, three inpatient rehabilitation services that manage some brain injury clients, two outpatient community rehabilitation teams, one specialist brain injury services transition/case management, and one acute neurosurgical ward. Of the 21 services audited, 18 (86%) services report assessing physical activity as part of their standard practice, while 15/21 (71%) report assessing if current physical activity guidelines were being met, and this was usually as part of patient history taking. **BRIDGES qualitative research with stakeholder groups:** In relation to acceptability of the WHO physical activity guidelines for adults living with disability, all stakeholder groups were overall accepting of the recommendations but identified that some with more severe injuries (cognitive, behavioural and/or physical impairments) may not be able to meet the recommended intensity and/or duration or may need additional support/equipment to achieve this. It was suggested resources that provide examples of how a range of different people with TBI meet these levels (and how to define moderate intensity activity) would be useful. It was also noted that the good practice points of the WHO guideline were very important. Participants discussed the acceptability of what might be considered more 'risky' activities for adults after msTBI: *"obviously very high risk, but it's positive risk and we've found there's a whole range of movement that comes specifically with surfing that you wouldn't get anywhere else. And those therapeutic benefits are a by-product of just having fun in the water."* (Exercise provider) *"we've actually started getting a few participants back into some more risky activities that they're sort of engaging with and that's actually increased their overall amount of physical activity because they realise that they can do some things that they did before, even if it's an adapted version of it."* (Service funder)	
Feasibility Is the intervention feasible to implement?		

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Health professionals, such as physiotherapists and exercise physiologists, are trained in the promotion of physical activity in rehabilitation settings. There are small inconsistencies in the current delivery e.g., only 15/21 (71%) services report assessing whether patients are meeting physical activity guidelines as a part of standard practice, though 18/21 (86%) report assessing their patient's physical activity levels. A high proportion of services report providing advice about the benefits of physical activity (20/21; 95%), physical activity guidelines (17/21; 81%) and the type and dose of physical activity recommended (19/21; 90%) as standard practice. All services report collaboratively developing goals with the patients, with most (18/21; 86%) also involving family members, and 16/21 (76%) involving carers, in the goal setting process. Finally, 16/21 (76%) services report providing interventions such as motivational interviewing, health coaching or behaviour change counselling when working with patients/clients to change their physical activity behaviour. **BRIDGES qualitative research with stakeholder groups:** To deliver overall physical activity in community settings may require specific resources (e.g., equipment, staff) and appropriate opportunities (e.g., inclusive or disability specific facilities and programs). Funding from state-based funders or NDIS may support this, however it would need to meet legislative requirements, fit within participant-developed goal and require submission of paperwork. *"The NDIS pays for the support worker to take her to the hydrotherapy. We pay for the pool cost, which, that's only $4 a time."* (Family member) *"the NDIS will fund modified recreational activities including equipment, but you need to clearly show that again it's reasonable and necessary and that what you're asking to do is not something like if you ask just to buy an e-bike, it has to be clearly linked to the fact that it's linked to your disability and what you're on the scheme for.* " (Service funder) **BRIDGES qualitative research with people with TBI:** Many participants valued encouragement and support for physical activity that countered the feeling of being injured. Psychological support was perceived as especially important in the earlier stages of recovery and rehabilitation where many gains were yet to be realised: *"I think the physios that sort of look after us in the gym have been quite good, for example, they've told me that, "Hey, you can't do this, but you might be able to do it in the future." So … the physio team is also quite a resource for me … they've really helped. So sometimes you actually don't believe that you can do things, but then people that you are with … can change*	Limited research has been conducted in those with high support needs, children, and Indigenous and CALD populations. Additional work on implementation of interventions that promote physical activity in these groups is needed to ensure suitability, acceptability, and effective way to deliver these interventions.

	your mindset over time…. and then you sort of realise you can, and then you actually try a bit harder because you believe you can." (P19) Unfortunately, some had encountered activity facilitators who were had little or no knowledge of brain injury and could be prescriptive, condescending, and judgemental: *"… they may unfortunately tend to steer you and, perhaps if they're not used to dealing people with disability, may be a little bit patronising."* (P18) *"I don't need people highlighting what I can't do in such a way that I feel like a failure…. it's really important that I have people who are nonjudgmental … [who] will give me suggestions and also be okay with what I can't do."* (P1) Moving from a highly structured, well-supported program of rehabilitation into self-directed physical activity was a considerable challenge and highlighted the importance of long-term physical activity to be discussed and planned as part of rehabilitation: "*… it was very apparent to me that I had to do more than what I was doing through my basic rehab….. I was very lucky. I was able to draw on knowledge that I had pre-accident. I've done a lot of internet searching, spoke to a lot of people, physios, but I'll be perfectly honest with you, I found very little out there to actually help…. as soon as you came out of the hospital there was outpatient stuff, but once you'd left that it was like, "Well, yeah, go to the gym, try and get fitter and healthier." But … there was no support. There was nothing there…. I wanted to make my own way. I didn't want somebody holding my hand whilst I was doing things, but equally, I wanted to feel secure in the environment that I was at…. It's a shame there isn't anything that helps us in that space between leaving hospital and obviously recovering."* (P3)	

SUMMARY OF FINDINGS TABLE

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	overall physical activity promotion	control	Relative (95% CI)	Absolute (95% CI)		
Physical activity at end of intervention (overall physical activity promotion vs. no intervention or non-active control) (follow-up: range 8 weeks to 12 weeks; assessed with: Actigraph-measured time in moderate-vigorous physical activity (1 study); self-report time in moderate-vigorous physical activity (1 study). More = better.)												
2	observational studies	very serious[a]	serious[b]	serious[c]	serious[d]	none	45	45	-	SMD **2.66 SD more** (1.18 more to 4.15 more)	⊕◯◯◯ Very low	CRITICAL
Physical Activity at end of follow-up (overall physical activity promotion vs. no intervention or non-active control) (follow-up: range 3 months to 6 months; assessed with: Actigraph-measured time in moderate-vigorous physical activity (1 study); self-report time in moderate-vigorous physical activity (1 study). More = better)												
2	observational studies	very serious[a]	serious[e]	serious[c]	very serious[d]	none	45	45	-	SMD **1.37 SD higher** (0.28 higher to 2.46 higher)	⊕◯◯◯ Very low	CRITICAL
Social connection - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	CRITICAL
Behaviour change - not reported												
-	-	-	-	-	-	-	-	-	-	-	-	CRITICAL
Quality of life - not measured												
-	-	-	-	-	-	-	-	-	-	-	-	CRITICAL
Comorbidities and mortality at end of intervention (overall physical activity promotion vs. non-active control) (follow-up: mean 12 months; assessed with: Systolic blood pressure (mmHg). Higher = worse)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**overall physical activity promotion**	**control**	**Relative (95% CI)**	**Absolute (95% CI)**		
1	randomised trials	not serious[f]	not serious	not serious	serious[d]	none	24	23	-	MD **1.2 mmHg lower** (9.73 lower to 7.33 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Participation at end of intervention (overall physical activity promotion vs. no intervention) (follow-up: mean 8 weeks; assessed with: Mayo-Portland Adaptability Inventory-4 - Participation subscale. Lower = better)												
1	observational studies	very serious[g]	not serious	serious[h]	serious[d]	none	22	25	-	MD **4.49 lower** (8.56 lower to 0.42 lower)	⨁◯◯◯ Very low	CRITICAL
Participation at end of follow-up (overall physical activity promotion vs. no intervention) (follow-up: mean 3 months; assessed with: Mayo-Portland Adaptability Inventory-4 - Participation subscale. Lower = better)												
1	observational studies	very serious[g]	not serious	serious[h]	serious[d]	none	22	25	-	MD **5.7 lower** (9.36 lower to 2.04 lower)	⨁◯◯◯ Very low	CRITICAL
Mood at end of first phase of cross-over randomised controlled trial (overall physical activity promotion vs. non-active control) (follow-up: 12 weeks; assessed with: Center for Epidemiological Studies-Depression scale. Lower = better.; Scale from: 0 to 60)												
1	randomised trials	very serious[i]	not serious	serious[j]	serious[k]	none	28	39	-	MD **3.11 lower** (8.11 lower to 1.89 higher)	⨁◯◯◯ Very low	CRITICAL

CI: confidence interval; **MD:** mean difference; **SMD:** standardised mean difference

Explanations

a. Downgraded two levels due to both studies being non-randomised studies of intervention, and serious concerns over the risk of bias of potential confounders and outcome measurements in one study, and moderate concerns over the risk of potential confounders for the other study.

b. Downgraded one level due to wide variance of point estimates, a high I square value (84%) and significant chi-squared test.

c. Downgraded one level due to one study using a self-report measure of moderate-vigorous physical activity, and both studies including mixed populations of brain injured participants (<50% TBI).

d. Downgraded one level due to small sample sizes.

e. Downgraded one level due to wide variance of point estimates, a high I square value (81%) and significant chi-squared test.

f. Low risk of bias for all domains of the ROB-2 except for the domain of deviations from the intended intervention due to the impact of COVID-19

g. Downgraded two levels due to the study being a non-randomised study of intervention, and serious concerns over the risk of bias of potential confounders and outcome measurements.

h. Downgraded one level due to only 8 of the 22 participants in the Intervention group and 11 of the 25 participants in the Control group being people with TBI.

i. Downgraded one level due to a high overall RoB as a result of unconcealed allocation sequence, unequal allocation to intervention and control groups, and participants and therapists were unblinded to the intervention.

j. Downgraded one level due to serious concerns for indirectness given 23 of the 68 enrolled participants were either mild TBI or their TBI severity was unknown.

k. Downgraded one level due to the small sample size (i.e., 28 only in Intervention, including a mix of mild, moderate and severe TBI, and unknown severity also).

FORREST PLOTS AND RISK OF BIAS ASSESSMENT

Outcome: Physical activity

Physical activity at end of intervention: (overall physical activity promotion vs. no intervention or non-active control)

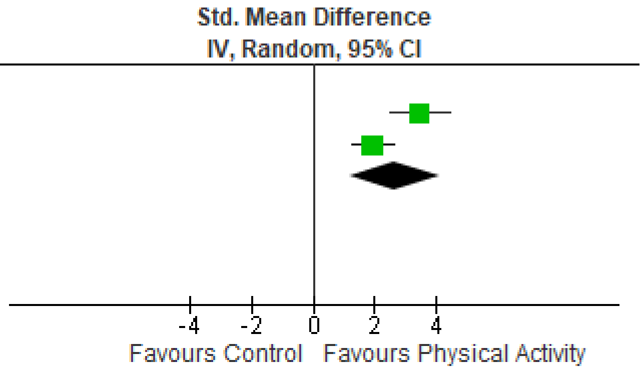
Risk of bias (ROBINS-I)

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
Clanchy 2016	?	+	+	+	+	+	+	?
Driver 2016	-	+	+	+	+	-	+	-

Forest plot: Actigraph-measured time in moderate-vigorous physical activity (1 NRSI); self-report time in moderate-vigorous physical activity (1 NRSI).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.2.1 Time in MVPA								
Clanchy 2016	31.2	3.1	23	19.6	3.5	20	47.4%	3.46 [2.49, 4.43]
Driver 2016	72.28	11.2	22	47.91	13.23	25	52.6%	1.94 [1.24, 2.65]
Subtotal (95% CI)			**45**			**45**	**100.0%**	**2.66 [1.18, 4.15]**

Heterogeneity: Tau² = 0.96; Chi² = 6.11, df = 1 (P = 0.01); I² = 84%
Test for overall effect: Z = 3.52 (P = 0.0004)



Physical activity at end of follow-up: (overall physical activity promotion vs. no intervention or non-active control)

Risk of bias (ROBINS-I)

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias

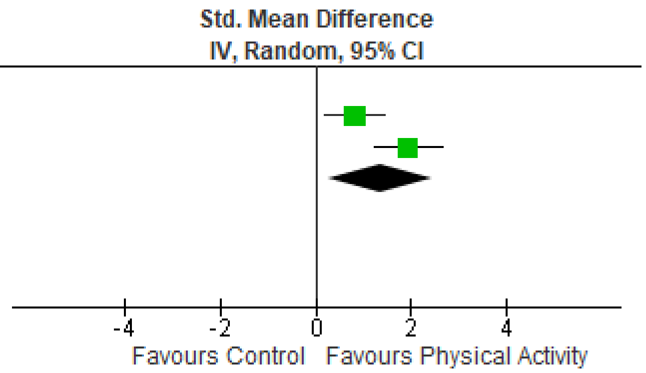
				intended interventions				
Clanchy 2016	?	+	+	+	+	+	+	?
Driver 2016	-	+	+	+	+	-	+	-

Forest plot: Actigraph-measured time in moderate-vigorous physical activity (1 NRSI); self-report time in moderate-vigorous physical activity (1 NRSI).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.3.1 Time in MVPA								
Clanchy 2016	25.3	3.2	23	22.5	3.5	20	51.1%	0.82 [0.20, 1.45]
Driver 2016	67.55	11.1	22	44.26	12.45	25	48.9%	1.93 [1.23, 2.64]
Subtotal (95% CI)			**45**			**45**	**100.0%**	**1.37 [0.28, 2.46]**

Heterogeneity: Tau² = 0.50; Chi² = 5.35, df = 1 (P = 0.02); I² = 81%

Test for overall effect: Z = 2.46 (P = 0.01)



Outcome: Social connection

No studies have measured this outcome.

Outcome: Behaviour change

No studies have measured this outcome.

Outcome: Quality of life

No studies have measured this outcome.

Outcome: Co-morbidities and mortality

Co-morbidities and mortality at end of intervention: (overall physical activity promotion vs. non-active control)

Risk of bias (ROB-2)

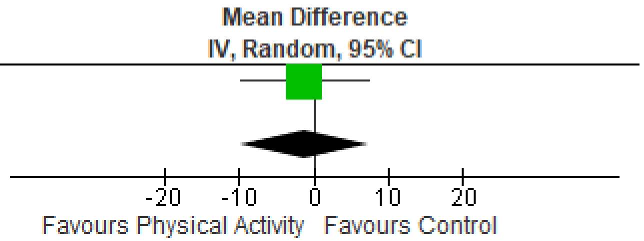
	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Driver 2023	+	+	-	+	+	?	+	+

Forest plot: Systolic blood pressure (mmHg) (1 RCT).

	Experimental			Control				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Driver 2023	123.9	13.7	24	125.1	16	23	100.0%	-1.20 [-9.73, 7.33]
Total (95% CI)			**24**			**23**	**100.0%**	**-1.20 [-9.73, 7.33]**

Heterogeneity: Not applicable

Test for overall effect: Z = 0.28 (P = 0.78)



Outcome: Participation

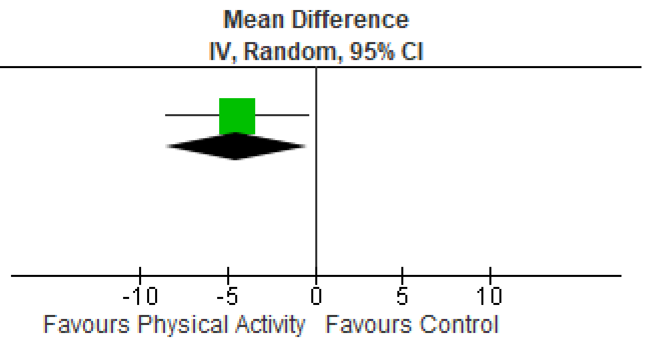
Participation at end of intervention: (overall physical activity promotion vs. no intervention)

Risk of bias (ROBINS-I)

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
Driver 2016	-	+	+	+	+	-	+	-

Forest plot: Mayo-Portland Adaptability Inventory-4 - Participation subscale (1 NRSI).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
2.5.1 End of Intervention								
Driver 2016	38.4	5.83	22	42.89	8.31	25	100.0%	-4.49 [-8.56, -0.42]
Subtotal (95% CI)			**22**			**25**	**100.0%**	**-4.49 [-8.56, -0.42]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.16 (P = 0.03)								



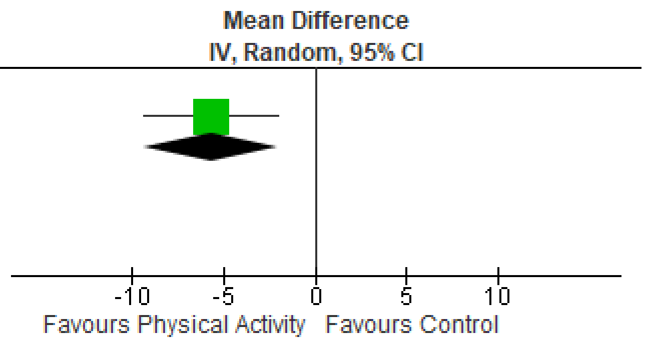
Participation at end of follow-up: (overall physical activity promotion vs. no intervention)

Risk of bias (ROBINS-I)

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall bias
Driver 2016	-	+	+	+	+	-	+	-

Forest plot: Mayo-Portland Adaptability Inventory-4 - Participation subscale (1 NRSI).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
2.6.1 End of Follow-up								
Driver 2016	35.62	5.67	22	41.32	7.11	25	100.0%	-5.70 [-9.36, -2.04]
Subtotal (95% CI)			**22**			**25**	**100.0%**	**-5.70 [-9.36, -2.04]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.05 (P = 0.002)								



Outcome: Mood

Mood at end of intervention: (overall physical activity promotion vs. non active control)

Risk of bias (ROB-2 Assessment for Crossover Trials)

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Bias arising from period or carry-over effects	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Objective outcomes	Blinding of outcome assessment (detection bias): Subjective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Driver 2023	+	-	+	-	+	?	?	?	+

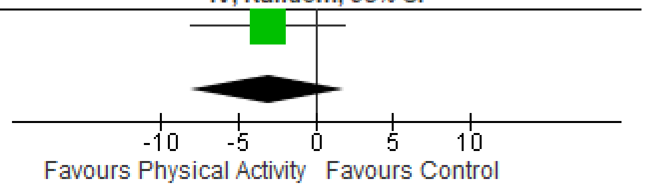
Forest plot: Center for Epidemiological Studies-Depression scale (1 Cross-over RCT).

	Experimental			Control				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Bellon 2015	12.04	9.367	28	15.15	11.479	39	100.0%	-3.11 [-8.11, 1.89]
Total (95% CI)			**28**			**39**	**100.0%**	**-3.11 [-8.11, 1.89]**

Heterogeneity: Not applicable

Test for overall effect: Z = 1.22 (P = 0.22)

Mean Difference
IV, Random, 95% CI



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Clinical question 10: Overall physical activity promotion for children and adolescents with moderate to severe traumatic brain injury

Clinical question

Should **overall physical activity promotion** compared to control be used for **children and adolescents** after moderate to severe traumatic brain injury?

Setting: Healthcare settings across the continuum of care:

- Inpatient, transition and outpatient rehabilitation settings
- Community settings (e.g., fitness centres, sporting fields, community centres)
- Home
- Schools

Perspective: Health systems

Outcomes of interest:

1.	Physical activity	CRITICAL
2.	Social connection	CRITICAL
3.	Behaviour change	CRITICAL
4.	Quality of life	CRITICAL
5.	Co-morbidities and mortality	CRITICAL
6.	Participation	CRITICAL
7.	Mood	CRITICAL

Conditional recommendation:

For children and adolescents after moderate to severe TBI, we suggest the promotion of physical activity across the continuum of care.

Good Practice Points:

We suggest:

- Health professionals initiate conversations with the child or adolescent and their family about a return to physical activity as early as possible, mindful of the potential for the early rehabilitation phase of recovery to be an opportune time to establish short and long-term goals, positive behaviours, and support systems.
- Physical activity is promoted with consideration of current public health physical activity guideline recommendations for children and adolescents living with disability.
- Pre-injury physical activity is assessed, and health professionals consider building on what a child or adolescent has done before (i.e., supporting a return to previous activity).
- Health professionals consider promoting opportunities for their clients to engage in physical activity within a fun and social setting e.g., play, school activities, sport.
- Physical activity is incorporated into weekly routines and key supports (e.g., siblings, friends, teachers, support workers, and parents) are trained in facilitating opportunities for activity.
- Health professionals seek to discuss barriers and facilitators to engaging in physical activity with the child or adolescent and key supports and implement strategies to support the uptake of physical activity.

Justification

Overall justification

Physical inactivity can lead to an array of negative health consequences for children and adolescents. Overall physical activity promotion can encourage children and adolescents after msTBI to be physically active.

Detailed justification

Problem

Children and adolescents after msTBI are commonly highly inactive, which can lead to impaired fitness, function and chronic health conditions later in life.

Desirable Effects

There is little condition and population specific evidence to inform this judgement. But the well-known benefits of physical activity apply to children and adolescents after msTBI.

Balance of effects

Trivial undesirable effects and potentially moderate desirable effects on critical and important outcomes.

Acceptability

Good acceptability from multiple stakeholders.

Feasibility

Feasible to deliver in inpatient and post-rehabilitation settings, although implementation support will be needed, especially for services and clinicians working with children and adolescents with higher support needs.

Copy of summary ratings on each criteria of the Evidence to Decision Framework, developed using GRADE-PRO software.

PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	**Trivial**	Small	Moderate	Large		Varies	Don't know
CERTAINTY OF EVIDENCE	Very low	Low	Moderate	High		No included studies	
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	**Probably no important uncertainty or variability**	No important uncertainty or variability			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	Negligible costs and savings	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	Moderate	High		No included studies	
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	No included studies
EQUITY	Reduced	Probably reduced	Probably no impact	**Probably increased**	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**		Varies	Don't know
FEASIBILITY	No	Probably no	**Probably yes**	Yes		Varies	Don't know

Criteria

Problem: Is the problem a priority? **Desirable effects**: How substantial are the desirable anticipated effects? **Undesirable effects**: How substantial are the undesirable anticipated effects? **Certainty of evidence**: What is the overall certainty of the evidence of effects? **Values**: Is there important uncertainty about or variability in how much people value the main outcomes? **Balance of effects**: Does the balance between desirable and undesirable effects favour the intervention of the comparison? **Resources required**: How large are the resource requirements (costs)? **Certainty of evidence of required resources**: What is the certainty of the evidence of resource requirements (costs)? **Cost effectiveness**: Does the cost-effectiveness of the intervention favour the intervention or the comparison? **Equity**: What would be the impact on health equity? **Acceptability**: Is the intervention acceptable to key stakeholders? **Feasibility**: Is the intervention feasible to implement? (Moberg et al., 2018)

ASSESSMENT

Problem Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	• Physical activity is associated with a 20%–30% lower risk in all-cause mortality and incidence of multiple chronic conditions (McKinney et al., 2016). The benefits of physical activity for children and adolescents are wide-ranging and well documented (Biddle et al., 2004). • Children and adolescents aged 5–17 years should accumulate at least 60 minutes per day of moderate- to vigorous-intensity physical activity, on average, and incorporate vigorous-intensity aerobic activities as well as muscle- and bone-strengthening activities at least 3 days per week (WHO, 2020). • Globally, children and adolescents have low levels of physical activity (Aubert et al., 2022). Children and adolescents after msTBI are even less physically active than their non-brain injured peers (Katz-Leurer et al., 2010). • Low levels of physical activity can have negative consequences after msTBI, including physical deconditioning, compromised aerobic capacity, and functional impairment, and can lead to chronic health conditions later in life (Hamel et al., 2019). • Several barriers to physical activity have been identified by children with disability onset during childhood. Barriers include personal (e.g., fatigue and motivation) and environmental (inappropriate equipment and lack of professional support) (Buffart et al., 2009).	Successful reintegration into physical activity such as active play, sport, exercise, and recreation is important for children and adolescents after msTBI. The ability to play sports and compete with their peers can provide a sense of accomplishment and acceptance (Rossi et al., 1996).
Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	There is no evidence to guide this judgement in children and adolescents in TBI research. **Evidence in adults with TBI:** Overall physical activity promotion had a large positive effect on levels of physical activity in adults after msTBI (low certainty evidence) (Clanchy et al., 2016; Driver et al., 2016). An overall physical activity promotion intervention may also improve participation in adults after msTBI, though the evidence is of very low certainty (Driver et al., 2016).	Nil.

	Evidence from WHO physical activity guidelines for disability (Carty et al., 2021): • WHO guideline development group considered the evidence for children without disability could be extrapolated for children living with disability for key outcomes including favourable outcomes on cardiorespiratory and muscular fitness, cardiometabolic health, bone health, cognitive outcomes, mental health, and adiposity. • WHO guideline development group considered evidence for physical activity for children living with intellectual disability and children with attention deficit hyperactivity disorder (ADHD). They found low-certainty evidence of improved physical function in children with intellectual disability and moderate-certainty evidence that moderate to vigorous physical activity can have beneficial effects on cognition, including attention, executive function, and social disorders in children with ADHD. The WHO guidelines recommend for children and adolescents (aged 5–17) living with disability it is recommended that: • Children and adolescents living with disability should do at least an average of 60 minutes per day of moderate to vigorous intensity, mostly aerobic, physical activity, across the week. *Strong recommendation, moderate certainty evidence*	

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know	There is no evidence to guide this judgement in children and adolescents in TBI research. **Evidence from adults with TBI:** No negative effects found on any of the critical or important outcomes. Adverse events (AEs) were not explicitly mentioned in all studies. Seven serious adverse events (SAEs) and 20 AEs were reported in a non-randomised study of intervention (Driver et al., 2023), though all were unrelated to the study protocol. **Evidence from WHO physical activity guidelines for disability (Carty et al., 2021):**	**Clinical expertise input:** Risk of seizures if still recovering from acute illness, anti-seizure medications not stable/routinely taken. **Cochrane review on exercise interventions in cerebral palsy (Ryan et al., 2017):** Thirteen trials did not report adverse events, seven reported no adverse events, and nine reported non-serious adverse events.

	The WHO guidelines suggest the following Good Practice Point for children and adolescents (aged 5–17) living with disability: • There are no major risks for children and adolescents living with disability engaging in physical activity when it is appropriate to an individual's current activity level, health status and physical function; and the health benefits accrued outweigh the risks.	
Certainty of evidence What is the overall certainty of the evidence of effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Very low ○ Low ○ Moderate ○ High ● No included studies	There is no evidence to guide this judgement in children and adolescents in TBI research. **Evidence from adults with TBI:** Most outcomes evaluated were rated as very low or low certainty evidence. The evidence for the effect of overall physical activity promotion on systolic blood pressure was considered moderate certainty.	Nil.
Values Is there important uncertainty about or variability in how much people value the main outcomes?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability	No specific research has been conducted in TBI to inform the value children and adolescents after msTBI (and their family) place on the main outcomes. **BRIDGES qualitative research with stakeholder groups:** Community-based opportunities that promote overall physical activity that requires the family to drive to the activity may be challenging for them to prioritise, particularly if there are other children and activities to juggle.	If children and adolescents can engage in an activity that promotes overall physical activity and enable them to participate alongside their peers, it is likely to be of value to them.

	".... so a person who has mobility issues, the day starts getting out of bed, getting into a chair, or getting ready, getting down the ramp into their house, into their car, driving to wherever they need to go, finding parking. If they need a high ab or something like that to transfer between wheelchairs, their car wheelchair to a beach wheelchair, getting down onto the beach in soft sand, getting into the water, and then the surf might not be cooperating that day and it might be quite dangerous to put somebody in the water, and then participating and then doing all the reverse of that to go home." (Exercise provider) *"families have got other priorities. So if you gave them that [WHO guideline recommendations] as the guideline, there's no way that they would say that that's something that they would be able to meet, particularly early on in their journey of traumatic brain injury. Maybe many, many years down the track, but definitely not early on."* (Health Professional) *"the ones that have succeeded are the ones where the client is motivated and you can find something really meaningful, salient to that individual. And often they come with that background and then they've got the family who are on board and are able to succeed. And it can be amazing, competitive, high-level athletics, or it can just be these families that they go fishing and they go kayaking and they're doing stuff all the time that's physical, even though it's not at a competitive or athletic level. And I think there's a lot of the children, a lot of family drive as well."* (Health Professional)	

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	Trivial or small undesirable effects and unknown desirable effects including potentially moderate effects on critical and important outcomes.	Nil.

Resources required

How large are the resource requirements (costs)?"

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	Cost data is not available from any studies in TBI. The cost of the required resources likely varies depending on the needs of the child or adolescent with TBI, e.g., if they can independently participate in physical activity, or if they need one-on-one supervision or specific equipment to facilitate their participation in the activity. A reduction in population level physical inactivity is likely to be cost saving for health system. **BRIDGES audit of brain injury services:** Six paediatric services across Australia (Location: 3/8 states and territories; all in major cities; 5 public, 1 private; 4 specialist inpatient brain injury rehabilitation, 1 inpatient rehabilitation service that manages some brain injury clients, 1 private practice). Of the six paediatric services audited, it was standard practice to assess their patients' physical activity levels in five services (83%) as part of their role in broadly promoting physical activity. For all these services, observation or history taking were the primary method for assessing physical activity levels. **BRIDGES qualitative research with stakeholder groups:** It was noted from multiple stakeholders the need for attendant care workers to support participation in physical activity (including sport and physical recreation) including supporting travel, motivation to do the activity, supervision of home or gym programs. *"I find one of the biggest barriers is if they're wanting to get back to community sport or engage in regular exercise that they may have been participating in prior to their injury and are really motivated to get back to that, some of the barriers around access and appropriate equipment, support to be able to get them there, often they're not driving. I think those things become quite difficult, so it's probably more so around appropriate equipment, access and support for transport."* (Health Professional) It was noted from health professionals and community physical activity providers, that specialised/adapted equipment is needed for those with higher support needs that either needs to be purchased for the person (or funded through funding bodies) or the person needs to attend a specialised service that has that equipment. *"There's a whole range of things, like hand cycling and recumbent bikes are a big passion of mine, so I love adapted bikes, that that's a great way to get people engaged, and that's just on a recreational level, and then we've got that cohort that want to go that little bit further and*	**BRIDGES audit of brain injury services:** 26 services across Australia (Location: 8/8 states and territories; 22 major cities, 2 regional, 2 outer regional or remote; 19 public, 3 private, 4 mixed services; 12 specialist brain injury services with inpatient service, 6 private practices that work with TBI clients, 4 inpatient rehabilitation services that manage some brain injury clients, 2 outpatient community rehabilitation teams, 1 specialist brain injury services transition/case management, 1 acute neurosurgical ward; Client type: 6 services children and adolescents, 21 working age adults, 14 older adults).

	get classified, and then try to go onto the Paralympics or compete, so cool." (Health Professional)	

Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Very low ○ Low ○ Moderate ○ High ● No included studies	No studies include cost data about the resources required.	Nil.

Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	There is no evidence to guide this judgement in TBI research.	Nil.

Equity What would be the impact on health equity?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Reduced ○ Probably reduced ○ Probably no impact ● Probably increased ○ Increased ○ Varies ○ Don't know	General population studies have shown lower levels of physical activity in lower socioeconomic areas. Indeed, socioeconomic position has been found to predict a decline in non-organised physical activity during adolescence (Kemp et al., 2021). Providing access and opportunities for children and adolescents after msTBI to participate in activities that promote overall physical activity will likely benefit those in more disadvantaged groups. Access to inpatient rehabilitation services is within public health system, so access for all is dependent on need, not funding. There is likely access to state-based funding and NDIS for any with moderate to severe injury (if meet inclusion criteria) to support sport and physical recreation post inpatient rehabilitation, but completion of forms etc for access to these funding schemes may be more challenging for those with lower socioeconomic backgrounds or less family support. National guidelines may support providers to deliver and funders to fund physical activity programs for those living in more regional, rural and remote areas that aren't as linked in with specialist brain injury services.	Nil.

Acceptability Is the intervention acceptable to key stakeholders?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Looking more closely at paediatric services, 5 of the 6 (83%) services reported assessing physical activity as part of their standard practice, and 3/6 (50%) reported assessing if current physical activity guidelines were being met as part of the patient's history taking. **BRIDGES qualitative research with stakeholder groups:** In relation to acceptability of the WHO physical activity guidelines for children and adolescents living with disability (Carty et al., 2021), all stakeholder groups were overall accepting of this but identified that some with more severe injuries (cognitive, behavioural and/or physical	Nil.

	impairments) may not be able to meet the recommended intensity and/or duration or may need additional support/equipment and time to achieve this. *"I think with the right person, the right attitude, the right help, they* (the WHO physical activity guidelines) *could be reached."* (Family member) *"... families have got other priorities. So if you gave them that as the guideline, there's no way that they would say that that's something that they would be able to meet, particularly early on in their journey of traumatic brain injury. Maybe many, many years down the track, but definitely not early on.*" (Health Professional) It was suggested resources that provide examples of how a range of different people after msTBI meet these levels (and how to define moderate intensity activity) would be useful. It was also noted that the good practice points of the WHO guideline were very important. *"I would discuss being physically active on every day, pick and choose elements of that. I would rarely talk about the number of minutes or intensity at the stage with most of my clients, but sitting less, moving more, those types of more general principles. Similarly to the second page [Good Practice Points], I might use something that's more like that. Yeah."* (Health Professional)	

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know	**BRIDGES audit of brain injury services:** Overall physical activity promotion seems feasible in rehabilitation settings when delivered by health professionals. Health professionals, such as physiotherapists and exercise physiologists, are trained in the promotion of physical activity in rehabilitation settings. There are inconsistencies in the current delivery. For example, only 3/6 (50%) services report assessing whether their patients are meeting physical activity guidelines as a part of standard practice, though 5/6 (83%), report assessing their patient's physical activity levels, mostly through the patient's history taking and observation. A high proportion of services report providing advice about the benefits of physical activity (6/6; 100%), physical activity guidelines (5/6; 83%), and the type and dose of physical activity recommended (5/6; 83%) as standard practice. All services report collaboratively developing goals with the patients and family, and with most (5/6; 83%) involving carers, in the goal setting process. Finally, 5/6 (83%) services report providing interventions such as motivational interviewing, health coaching or behaviour change counselling when working with patients/clients to change their physical activity behaviour.	Nil.

	Barriers to delivering overall physical activity promotion included a lack of knowledge, skills, and time - all reported by 4 of the 6 (66%) services. **BRIDGES qualitative research with stakeholder groups:** To deliver overall physical activity in community settings may require specific resources (e.g., equipment, staff) and appropriate opportunities (e.g., inclusive or disability specific facilities and programs). Funding from state-based funders or NDIS may support this, however it would need to meet legislative requirements, fit within participant-developed goal and require submission of paperwork. *"The NDIS pays for the support worker to take her to the hydrotherapy. We pay for the pool cost, which, that's only $4 a time."* (Family member) *"the NDIS will fund modified recreational activities including equipment, but you need to clearly show that again it's reasonable and necessary and that what you're asking to do is not something like if you ask just to buy an e-bike, it has to be clearly linked to the fact that it's linked to your disability and what you're on the scheme for.*" (Service funder) Opportunities to participate in overall physical activity are likely to arise in the school setting. There needs to be a willingness of schools to engage with outside providers (e.g., health professionals) and to see the importance of physical activity as part of the education curriculum for children and adolescents living with disabilities such as TBI. *"One of the facilitators can be the schooling environment. If you've got the right people in the schooling environment that can help promote physical activity in a way that is enjoyable, successful, meaningful, then that means their participation in those areas can be positively influenced, rather than them sitting out on things or timekeeping or keeping score, any of those terrible things."* (Health Professional)	

SUMMARY OF FINDINGS TABLE, FOREST PLOTS AND RISK OF BIAS ASSESSMENT

No studies measured any of the critical or important outcomes identified for this intervention. Therefore, no summary of findings tables, forest plots or risk of bias were completed for this clinical question.

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Appendices

Appendix 1: Identification of credible existing guidelines

CRITERIA	GUIDELINES												
	WHO Guidelines[1]	*UK PA Guidelines*[2]	*GN Guideline*	*Americans PA Guidelines*[4]	*NF Guideline*	*CI Guidelines*	*BSRM Guidelines*[7]	*CI Positio Stand*[8]	*MS Guidelines*[9]	*Z Guidelines*[10]	*Stroke Guidelines*[11]	*CP Motor Rehab Guidelines*[12]	*Children and Young People CP Guidelines*[13]
Published in last 10 years	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes
Followed GRADE Process	Yes	Yes	No	No	No	Yes	No	No	No	No	Yes	Unsure	Yes
Addresses clear questions (can identify PICO elements)	Yes	No	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Has benefits and harms assessments for patient-important outcomes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assessed using AGREE	No	No	No	No	No	Yes	No	No	Yes	No	No	Yes	No
Allows for updating (e.g., present full systematic reviews, accessible search strategy, analysis method)	Yes	No	No	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Has existing and accessible evidence-tables/summaries	Yes	No	No	No	No	Yes	No	No	No	Yes	Yes	Unsure	Yes
Has risk of bias assessment	Yes	No	No	Yes	No	Yes	No	No	No	No	Yes	No	Yes
Costs associated with implementing guideline	Yes	No	Yes	No	No	Yes	No	No	Yes	No	Yes	No	Yes

Accompany - how they are going to implement - disseminate the guidelines	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes

WHO, World Health Organisation; UK, United Kingdom; PA, Physical Activity; SIGN, Scottish Intercollegiate Guidelines Network; ONF, Ontario Neurotrauma Foundation; SCI, Spinal Cord Injury; BSRM, British Society of Rehabilitation Medicine; MS, Multiple Sclerosis; NZ, New Zealand; CP, Cerebral Palsy; GRADE, Grading of Recommendations Assessment, Development and Evaluation; AGREE, Appraisal of Guidelines, Research and Evaluation.

AGREE-II[14]		**Children and Young People CP Guidelines[13]**		**WHO Guidelines[1]**		**Stroke Guidelines[11]**	
Section	**Item**	**Appraiser 2**	**Appraiser 1**	**Appraiser 2**	**Appraiser 1**	**Appraiser 1**	**Appraiser 2**
Scope and Purpose	1	7	7	7	7	7	7
Scope and Purpose	2	7	7	7	7	7	7
Scope and Purpose	3	7	7	7	7	7	7
Stakeholder Involvement	4	6	7	7	7	7	7
Stakeholder Involvement	5	7	7	6	7	7	7
Stakeholder Involvement	6	7	7	7	7	7	7
Rigour of Development	7	7	7	6	6	7	5
Rigour of Development	8	7	7	7	7	6	6
Rigour of Development	9	7	7	7	7	7	7

Rigour of Development	10	7	7	7	7	6	7
Rigour of Development	11	7	7	7	7	7	7
Rigour of Development	12	7	7	7	7	7	7
Rigour of Development	13	7	6	6	7	7	4
Rigour of Development	14	4	6	6	6	7	7
Clarity of Presentation	15	7	7	7	7	6	6
Clarity of Presentation	16	7	6	7	6	6	7
Clarity of Presentation	17	7	7	7	7	5	6
Applicability	18	6	7	4	7	6	7
Applicability	19	7	7	5	7	6	7
Applicability	20	7	7	7	7	6	6
Applicability	21	2	5	5	7	7	7
Editorial Independence	22	7	7	5	6	6	7
Editorial Independence	23	7	7	7	7	6	7
Overall Assessment	OA1	6	7	7	7	6	6
Overall Assessment	OA2	Yes	Yes with modifications	Yes	Yes	Yes with modifications	Yes with modifications

AGREE, Appraisal of Guidelines, Research and Evaluation; CP, Cerebral Palsy; WHO, World Health Organisation; OA, Overall Assessment.

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Appendix 2: WHO Search Update

EVIDENCE PROFILE

Outcome	Systematic review evidence Review credibility	Quality Assessment No. of studies/Study design No. of participants	Risk of bias	Inconsistency	Indirectness	Imprecision	Other	Description of evidence Summary of findings	Certainty	Explanation
Physical function	Clark 2021 Moderate	21 RCTs N= 1412	No serious Risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	Publication bias strongly suspected	Mean age ranged from 44 to 76.5 years. Participants included patients both in the acute and chronic phase of stroke. The duration of rehabilitation ranged from two weeks to six months. Minutes of rehabilitation per week ranged from 90 to 1288, with frequency ranging from three to seven days per week. Interventions included physiotherapy, occupational therapy, neuromuscular electrical stimulation and task specific training. Additional time spent in rehabilitation was not associated with improvements in ADL outcome immediately after intervention. There was also no beneficial effect found on activity measures of the upper or lower limb, or motor impairment measures of the supper limb. The review did find a beneficial effect of additional time spent in rehabilitation for motor impairment measures of the lower limb immediately after intervention [SMD 0.71 (95% CI 0.15-1.28); p=0.01; 1 study, n=51; very low-certainty evidence].	LOW	Certainty of evidence downgraded given, serious imprecision (wide confidence intervals, small sample sizes) and publication bias

	Saunders 2020 Low	26 RCTs N-1235	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	Publication bias undetected	Cardiorespiratory fitness training interventions ranged from 2 to 24 weeks, session frequency ranged from 2 to 5 days per week, and session duration from 7 to 60 minutes. Interventions included treadmill and overground walking training, cycle ergometry and circuit training. Two studies found that cardiorespiratory training was beneficial for overall function assessed by the Rivermead Mobility Index (MD 1.56, 95% CI 0,2 to 2.92, p=0.02). However, no effect was found using the Functional Independence Measure and Barthel Index. Meta-analysis of nine studies (n=317) found training was associated with a significant increase in cardiorespiratory fitness (MD 3.40 mL/ kg/minute, 95% CI 2.98 to 3.83; p = 0.00001). Training was also associated with improvements in balance (MD 1.92, 95% CI 0.16 to 3.68; P = 0.03, 7 studies, n=471) and functional outcomes as indicated by the Timed Up and Go test (MD −3.42 sec, 95% CI −4.78 to −2.05; P value 0.00001, 5 studies, n=223) and 6 minute walk test (MD +33.41 metres/6 minutes, 95% CI 19.04 to 47.78; P = 0.00001, 16 studies, n=882).	MODERATE	Certainty of evidence downgraded due to serious imprecision (wide confidence intervals)

	Thijs 2023 High	20 RCTs N=662	Serious risk of bias	Serious inconsistency	No serious indirectness	Serious imprecision	Publication bias strongly suspected	Mean age in the experimental group ranged from 44 years to 75 years. Mean age in the control group ranged from 48 to 76 years. Total time training ranged from 30 minutes to 45 hours. Interventions included core-stability training, electrical stimulation, selective-trunk training, sitting-reaching therapy, trunk balance training and weight shifting training. Trunk training was associated with improved activities of daily living when compared to a control group that received non-dose-matched therapy (SMD 0.96 , 95% CI 0.69 to 1.24, p < 0.001, 5 trials, n-283). A positive effect was also found in trunk function (SMD 1.49,95% CI 1.26 to 1.71; P < 0.001; 14 trials, n=466), arm-hand function (SMD 0.67, 95% CI 0.19 to 1.15; P = 0.006; 2 trials, n=74), arm hand activity (SMD 0.84, 95% CI 0.009 to 1.59; P = 0.03; 1 trial, n=30), standing balance (SMD 0.57, 95% CI 0.35 to 0.79; P < 0.001; 11 trials, n=410) leg function (SMD 1.10, 95% CI 0.57 to 1.63; P < 0.001; 1 trial, n=64), and walking ability (SMD 0.73, 95% CI 0.52 to 0.94; P < 0.001; 11 trials, n=383)	VERY LOW	Certainty of evidence downgraded given serious risk of bias, serious inconsistency, serious imprecision and serious publication bias

Cognition	Lin 2022 Low	22 RCTs N= 1,601	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	Publication bias strongly suspected	Average age was 63 years. Women made up 40% of the sample. Time from stroke to intervention ranged from <1 week to over 6 years. Physical activity interventions ranged from 4 to 72 weeks, 15-240minuntes per day, 2-5 times per week. Trials investigated aerobic training, strength/balance/stretching/physiotherapy and combined training. Control groups included usual care, PA without a primary aerobic component and additional non-PA intervention. Physical activity was associated with a significant and positive effect on general cognition [SMD 0.2 (95% CI 0.12-0.27), p<0.001; 22 trials; n=1601].	MODERATE	Certainty of evidence downgraded given serious indirectness (intervention protocols)
Quality of life	Saunders 2020 Low	4 RCTs N=271	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	Publication bias undetected	Mean age ranged from 63 to 73 years in the intervention group and 63 to 70 years in the control group. Training interventions ranged from 8 to 16 weeks, frequency of session ranged from 2-3 times per week and session duration from 15 to 60 minutes. Interventions included overground and treadmill walking and cycling. Meta-analysis of two studies showed that cardiorespiratory training was associated with a benefit for the 'physical health' component of the SF-12 and SF-36 scale (SMD 0.51, 95% CI 0.2 to 0.82, p=0.001, 2 studies, n=164), but not the 'mental health' component. Two studies showed no pooled effect of training on EuroQoL scores.	MODERATE	Certainty of evidence downgraded given serious imprecision (wide confidence intervals)

	Thijs 2023 High	2 RCTs N=108	Serious risk of bias	Serious inconsistency	No serious indirectness	Serious imprecision	None	Mean age ranged from 51 to 60 years in experimental groups, and 63 to 66 years in the control groups. Mean time post-stroke ranged from 51 days to >3 months in the experimental group and 55 days to >3 months in the control group. Total duration ranged from 6-8 weeks, frequency 3-5 times per week, session duration 65-90 minutes. Interventions included neuromuscular electrical stimulation and video-game based therapy. Trunk training was associated with improved quality of life when compared to a control group that received non-dose-matched therapy (SMD 0.50, 95% CI 0.11 to 0.89; P = 0.01; 2 trials, n=108).	VERY LOW	Certainty of evidence downgraded due to serious risk of bias, serious inconsistency and serious imprecision (small sample size)
Mood	Saunders 2020 Low	2 RCTS N=56	Serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	None	Mean age ranged from 52 to 58 years in the intervention groups and 53 to 56 in the control groups. Physical activity interventions ranged from 4 to 12 weeks, intervention frequent 2-3 times per week and session duration 20 to 60 minutes. Trials investigated aquatic physical training and treadmill training. The analysis showed no beneficial effect of cardiorespiratory training on mood.	LOW	Certainty of evidence downgraded given serious risk of bias and serious imprecision (small sample size)

SYSTEMATIC REVIEWS DATA EXTRACTION

Systematic Review and Meta-Analysis **Citation**: Clark B, Whitall J, Kwakkel G, Mehrholz J, Ewings S, Burridge J. The effect of time spent in rehabilitation on activity limitation and impairment after stroke. *Cochrane Database Syst Rev*. 2021; 10(10): CD012612.	
Purpose: To assess the effect of 1. more time spent in the same type of rehabilitation on activity	**Background:** Stroke affects millions of people every year and is a leading cause of disability, resulting in significant financial cost and reduction in quality of life. Rehabilitation after stroke aims to reduce disability by facilitating recovery of impairment, activity, or

measures in people with stroke; 2. difference in total rehabilitation time (in minutes) on recovery of activity in people with stroke; and 3. rehabilitation schedule on activity in terms of: a. average time (minutes) per week undergoing rehabilitation, b. frequency (number of sessions per week) of rehabilitation, and c. total duration of rehabilitation. **Timeframe:** Inception - June 2021 **Total # studies included:** 21 **Other details (e.g. definitions used, exclusions etc)** Participants were adults (aged over 18 years), with a clinical diagnosis of stroke, caused by either infarct or haemorrhage (including subarachnoid haemorrhage), as defined by the study authors. Participants received rehabilitation in an inpatient, outpatient, or community setting. We excluded studies that included participants with diagnoses other than stroke as the primary diagnosis, even if they included some participants with a primary diagnosis of stroke. Comparisons of intervention versus no intervention (including trials in which just some participants received no intervention), were excluded. **Outcomes addressed:** Physical function	participation. One aspect of stroke rehabilitation that may affect outcomes is the amount of time spent in rehabilitation, including minutes provided, frequency (i.e. days per week of rehabilitation), and duration (i.e. time period over which rehabilitation is provided). Effect of time spent in rehabilitation after stroke has been explored extensively in the literature, but findings are inconsistent. Previous systematic reviews with meta-analyses have included studies that differ not only in the amount provided, but also type of rehabilitation. **Objectives:** To assess the effect of 1. more time spent in the same type of rehabilitation on activity measures in people with stroke; 2. difference in total rehabilitation time (in minutes) on recovery of activity in people with stroke; and 3. rehabilitation schedule on activity in terms of: a. average time (minutes) per week undergoing rehabilitation, b. frequency (number of sessions per week) of rehabilitation, and c. total duration of rehabilitation. **Search methods:** We searched the Cochrane Stroke Group trials register, CENTRAL, MEDLINE, Embase, eight other databases, and five trials registers to June 2021. We searched reference lists of identified studies, contacted key authors, and undertook reference searching using Web of Science Cited Reference Search. **Selection criteria:** We included randomised controlled trials (RCTs) of adults with stroke that compared different amounts of time spent, greater than zero, in rehabilitation (any non-pharmacological, non-surgical intervention aimed to improve activity after stroke). Studies varied only in the amount of time in rehabilitation between experimental and control conditions. Primary outcome was activities of daily living (ADLs); secondary outcomes were activity measures of upper and lower limbs, motor impairment measures of upper and lower limbs, and serious adverse events (SAE)/death. **Data collection and analysis:** Two review authors independently screened studies, extracted data, assessed methodological quality using the Cochrane RoB 2 tool, and assessed certainty of the evidence using GRADE. For continuous outcomes using different scales, we calculated pooled standardised mean difference (SMDs) and 95% confidence intervals (CIs). We expressed dichotomous outcomes as risk ratios (RR) with 95% CIs. **Main results:** The quantitative synthesis of this review comprised 21 parallel RCTs, involving analysed data from 1412 participants. Time in rehabilitation varied between studies. Minutes provided per week were 90 to 1288. Days per week of rehabilitation were three to seven. Duration of rehabilitation was two weeks to six months. Thirteen studies provided upper limb rehabilitation, five general rehabilitation, two mobilisation training, and one lower limb training. Sixteen studies examined participants in the first six months following stroke; the remaining five included participants more than six months poststroke. Comparison of stroke severity or level of impairment was limited due to variations in measurement. The risk of bias assessment suggests there were issues with the methodological quality of the included studies. There were 76 outcome-level risk of bias assessments: 15 low risk, 37 some concerns, and 24 high risk. When comparing groups that spent more time versus less time in rehabilitation immediately after intervention, we found no difference in rehabilitation for ADL outcomes (SMD 0.13, 95% CI -0.02 to 0.28; P = 0.09; I2 = 7%; 14 studies, 864 participants; very low-certainty evidence), activity measures of the upper limb (SMD 0.09, 95% CI -0.11 to 0.29; P = 0.36; I2 = 0%; 12 studies, 426 participants; very low-certainty evidence), and activity measures of the lower limb (SMD 0.25, 95% CI -0.03 to 0.53; P = 0.08; I2 = 48%; 5 studies, 425 participants; very low-certainty evidence). We found an effect in favour of more time in rehabilitation for motor impairment measures of the upper limb (SMD 0.32, 95% CI 0.06 to

	0.58; P = 0.01; I2 = 10%; 9 studies, 287 participants; low-certainty evidence) and of the lower limb (SMD 0.71, 95% CI 0.15 to 1.28; P = 0.01; 1 study, 51 participants; very low-certainty evidence). There were no intervention-related SAEs. More time in rehabilitation did not affect the risk of SAEs/death (RR 1.20, 95% CI 0.51 to 2.85; P = 0.68; I2 = 0%; 2 studies, 379 participants; low-certainty evidence), but few studies measured these outcomes. Predefined subgroup analyses comparing studies with a larger difference of total time spent in rehabilitation between intervention groups to studies with a smaller difference found greater improvements for studies with a larger difference. This was statistically significant for ADL outcomes (P = 0.02) and activity measures of the upper limb (P = 0.04), but not for activity measures of the lower limb (P = 0.41) or motor impairment measures of the upper limb (P = 0.06). **Authors' conclusions:** An increase in time spent in the same type of rehabilitation after stroke results in little to no difference in meaningful activities such as activities of daily living and activities of the upper and lower limb but a small benefit in measures of motor impairment (low- to very low-certainty evidence for all findings). If the increase in time spent in rehabilitation exceeds a threshold, this may lead to improved outcomes. There is currently insufficient evidence to recommend a minimum beneficial daily amount in clinical practice. The findings of this study are limited by a lack of studies with a significant contrast in amount of additional rehabilitation provided between control and intervention groups. Large, well-designed, high-quality RCTs that measure time spent in all rehabilitation activities (not just interventional) and provide a large contrast (minimum of 1000 minutes) in amount of rehabilitation between groups would provide further evidence for effect of time spent in rehabilitation.

Systematic Review and Meta-Analysis **Citation**: Saunders DH, Sanderson M, Hayes S, Johnson L, Kramer S, Carter DD, Jarvis H, Brazzelli M, Mead GE. Physical fitness training for stroke patients. *Cochrane Database Syst Rev.* 2020; Issue 3. Art. No: CD003316.	
Purpose: To determine whether fitness training after stroke reduces death, death or dependence, and disability. The secondary objectives were to determine the effects of training on adverse events, risk factors, physical fitness, mobility, physical function, health status and quality of life, mood, and cognitive function. **Timeframe:** Inception - July 2018 **Total # studies included:** 75 **Other details (e.g. definitions used, exclusions etc)** Studies that focused on different types of standard rehabilitation techniques but did not include a	**Background:** Levels of physical activity and physical fitness are low after stroke. Interventions to increase physical fitness could reduce mortality and reduce disability through increased function. **Objectives:** The primary objectives of this updated review were to determine whether fitness training after stroke reduces death, death or dependence, and disability. The secondary objectives were to determine the effects of training on adverse events, risk factors, physical fitness, mobility, physical function, health status and quality of life, mood, and cognitive function. **Search methods:** In July 2018 we searched the Cochrane Stroke Trials Register, CENTRAL, MEDLINE, Embase, CINAHL, SPORTDiscus, PsycINFO, and four additional databases. We also searched ongoing trials registers and conference proceedings, screened reference lists, and contacted experts in the field. **Selection criteria:** Randomised trials comparing either cardiorespiratory training or resistance training, or both (mixed training), with usual care, no intervention, or a non-exercise intervention in stroke survivors.

physical fitness training component were excluded. Studies that combined fitness training with assistive technologies, such as robotic and electromechanical-assisted gait training devices during body weight-supported locomotor training, as well as studies investigating virtual reality approaches were excluded. Studies that compared upper and lower body training were excluded if an additional non-exercise control group was not considered. Comparisons of intervention versus no intervention (including trials in which just some participants received no intervention), were excluded. **Outcomes addressed:** Physical function, quality of life	**Data collection and analysis:** Two review authors independently selected studies, assessed quality and risk of bias, and extracted data. We analysed data using random-effects meta-analyses and assessed the quality of the evidence using the GRADE approach. Diverse outcome measures limited the intended analyses. **Main results:** We included 75 studies, involving 3017 mostly ambulatory participants, which comprised cardiorespiratory (32 studies, 1631 participants), resistance (20 studies, 779 participants), and mixed training interventions (23 studies, 1207 participants). Death was not influenced by any intervention; risk differences were all 0.00 (low-certainty evidence). There were few deaths overall (19/3017 at end of intervention and 19/1469 at end of follow-up). None of the studies assessed death or dependence as a composite-outcome. Disability scores were improved at end of intervention by cardiorespiratory training (standardised mean difference (SMD) 0.52,95% CI 0.19 to 0.84; 8 studies, 462 participants; P = 0.002; moderate-certainty evidence) and mixed training (SMD 0.23, 95% CI 0.03 to 0.42; 9studies, 604 participants; P = 0.02; low-certainty evidence). There were too few data to assess the effects of resistance training on disability. Secondary outcomes showed multiple benefits for physical fitness (VO2 peak and strength), mobility (walking speed) and physical function(balance). These physical effects tended to be intervention-specific with the evidence mostly low or moderate certainty. Risk factor data were limited or showed no effects apart from cardiorespiratory fitness (VO2 peak), which increased after cardiorespiratory training (mean difference (MD) 3.40 mL/kg/min, 95% CI 2.98 to 3.83; 9 studies, 438 participants; moderate-certainty evidence). There was no evidence of any serious adverse events. Lack of data prevents conclusions about effects of training on mood, quality of life, and cognition. Lack of data also meant benefits at follow-up (i.e., after training had stopped) were unclear but some mobility benefits did persist. Risk of bias varied across studies but imbalanced amounts of exposure in control and intervention groups was a common issue affecting many comparisons. **Authors' conclusions:** Few deaths overall suggest exercise is a safe intervention but means we cannot determine whether exercise reduces mortality or the chance of death or dependency. Cardiorespiratory training and, to a lesser extent mixed training, reduce disability during or after usual stroke care; this could be mediated by improved mobility and balance. There is sufficient evidence to incorporate cardiorespiratory and mixed training, involving walking, within post-stroke rehabilitation programmes to improve fitness, balance and the speed and capacity of walking. The magnitude of VO2 peak increase after cardiorespiratory training has been suggested to reduce risk of stroke hospitalisation by ˜7%. Cognitive function is under-investigated despite being a key outcome of interest for patients. Further well-designed randomised trials are needed to determine the optimal exercise prescription, the range of benefits and any long-term benefits.

Systematic Review and Meta-Analysis **Citation**: Thijs L, Voets E, Denissen S, Mehrholz J, Elsner B, Lemmens R, Verheyden GSAF. Trunk training following stroke. *Cochrane Database Syst Rev.* 2020; Issue 3. Art. No: CD013712.	
Purpose: To assess the effectiveness of trunk training after stroke on activities of daily living (ADL), trunk function, arm-hand function or activity, standing balance, leg function, walking ability, and quality of life when comparing with both dose-matched as non-dose-matched control groups **Timeframe:** Inception - October 2021	**Background:** Previous systematic reviews and randomised controlled trials have investigated the effect of post-stroke trunk training. Findings suggest that trunk training improves trunk function and activity or the execution of a task or action by an individual. But it is unclear what effect trunk training has on daily life activities, quality of life, and other outcomes. **Objectives:** To assess the effectiveness of trunk training after stroke on activities of daily living (ADL), trunk function, arm-hand function or activity, standing balance, leg function, walking ability, and quality of life when comparing with both dose-matched as non-dose-matched control groups

Total # studies included: 68	**Search methods:** We searched the Cochrane Stroke Group Trials Register, CENTRAL, MEDLINE, Embase, and five other databases to 25 October 2021. We searched trial registries to identify additional relevant published, unpublished, and ongoing trials. We hand searched the bibliographies of included studies. **Selection criteria:** We selected randomised controlled trials comparing trunk training versus non-dose-matched or dose-matched control therapy including adults (18 years or older) with either ischaemic or haemorrhagic stroke. Outcome measures of trials included ADL, trunk function, arm-hand function or activity, standing balance, leg function, walking ability, and quality of life. **Data collection and analysis:** We used standard methodological procedures expected by Cochrane. Two main analyses were carried out. The first analysis included trials where the therapy duration of control intervention was non-dose matched with the therapy duration of the experimental group and the second analysis where there was comparison with a dose-matched control intervention (equal therapy duration in both the control as in the experimental group). **Main results:** We included 68 trials with a total of 2585 participants. In the analysis of the non-dose-matched groups (pooling of all trials with different training duration in the experimental as in the control intervention), we could see that trunk training had a positive effect on ADL (standardised mean difference (SMD) 0.96; 95% confidence interval (CI) 0.69 to 1.24; P < 0.001; 5 trials; 283 participants; very low-certainty evidence), trunk function (SMD 1.49, 95% CI 1.26 to 1.71;P < 0.001; 14 trials, 466 participants; very low-certainty evidence), arm-hand function (SMD 0.67, 95% CI 0.19 to 1.15; P = 0.006; 2 trials, 74 participants; low-certainty evidence), arm-hand activity (SMD 0.84, 95% CI 0.009 to 1.59; P = 0.03; 1 trial, 30 participants; very low-certainty evidence), standing balance (SMD 0.57, 95% CI 0.35 to 0.79; P < 0.001; 11 trials, 410 participants; very low-certainty evidence), leg function (SMD 1.10, 95% CI 0.57 to 1.63; P < 0.001; 1 trial, 64 participants; very low-certainty evidence), walking ability (SMD 0.73, 95% CI 0.52 to0.94; P < 0.001; 11 trials, 383 participants; low-certainty evidence) and quality of life (SMD 0.50, 95% CI 0.11 to 0.89; P = 0.01; 2 trials, 108 participants; low-certainty evidence). Non-dose-matched trunk training led to no difference for the outcome serious adverse events (odds ratio: 7.94, 95% CI 0.16 to 400.89; 6 trials, 201 participants; very low-certainty evidence). In the analysis of the dose-matched groups (pooling of all trials with equal training duration in the experimental as in the control intervention), we saw that trunk training had a positive effect on trunk function (SMD 1.03, 95% CI 0.91 to 1.16; P < 0.001; 36 trials, 1217participants; very low-certainty evidence), standing balance (SMD 1.00, 95% CI 0.86 to 1.15; P < 0.001; 22 trials, 917 participants; very low-certainty evidence), leg function (SMD 1.57, 95% CI 1.28 to 1.87; P < 0.001; 4 trials, 254 participants; very low-certainty evidence), walking ability (SMD 0.69, 95% CI 0.51 to 0.87; P < 0.001; 19 trials, 535 participants; low-certainty evidence) and quality of life (SMD 0.70, 95% CI0.29 to 1.11; P < 0.001; 2 trials, 111 participants; low-certainty evidence), but not for ADL (SMD 0.10; 95% confidence interval (CI) -0.17 to0.37; P = 0.48; 9 trials; 229 participants; very low-certainty evidence), arm-hand function (SMD 0.76, 95% CI -0.18 to 1.70; P = 0.11; 1 trial,19 participants; low-certainty evidence), arm-hand activity (SMD 0.17, 95% CI -0.21 to 0.56; P = 0.38; 3 trials, 112 participants; very low-certainty evidence). Trunk training also led to no difference for the outcome serious adverse events (odds ratio (OR): 7.39, 95% CI 0.15 to372.38; 10 trials, 381 participants; very low-certainty evidence).
Other details (e.g. definitions used, exclusions etc) Trials including other diseases in addition to stroke were excluded, unless they reported separate results for the stroke participants of interest. Cross-over RCTs were not included. If trunk training was embedded in a broader training concept, such as circuit training or a general strength programme, this study was excluded from this review	
Outcomes addressed: Physical function, quality of life	

	Time post stroke led to a significant subgroup difference for standing balance (P < 0.001) in non-dose-matched therapy. In non-dose-matched therapy, different trunk therapy approaches had a significant effect on ADL (< 0.001), trunk function (P < 0.001) and standing balance (< 0.001).When participants received dose-matched therapy, analysis of subgroup differences showed that the trunk therapy approach had a significant effect on ADL (P = 0.001), trunk function (P < 0.001), arm-hand activity (P < 0.001), standing balance (P = 0.002), and leg function (P = 0.002). Also, for dose-matched therapy, subgroup analysis for time post stroke resulted in a significant difference for the outcomes standing balance (P < 0.001), walking ability (P = 0.003) and leg function (P < 0.001), time post stroke significantly modified the effect of intervention. Core-stability trunk (15 trials), selective-trunk (14 trials) and unstable-trunk (16 trials) training approaches were mostly applied in the included trials. **Authors' conclusions:** There is evidence to suggest that trunk training as part of rehabilitation improves ADL, trunk function, standing balance, walking ability, upper and lower limb function, and quality of life in people after stroke. Core-stability, selective-, and unstable-trunk training were the trunk training approaches mostly applied in the included trials. When considering only trials with a low risk of bias, results were mostly confirmed, with very low to moderate certainty, depending on the outcome.

Systematic Review and Meta-Analysis **Citation**: Lin H, Liu HH, Dai Y, Yin X, Li Z, Yang L, Tao J, Liu W, Chen L. Effect of physical activity on cognitive impairment in patients with cerebrovascular diseases: a systematic review and meta-analysis. *Front Neurol.* 2022; 13: 854158.	
Purpose: This study investigates the effect of physical activity (PA) on cognition in patients with cerebrovascular disease and explored the maximum benefit of different PA characteristics. **Timeframe:** Inception - May 2021 **Total # studies included:** 22 **Other details (e.g. definitions used, exclusions etc)** Included subjects cannot have other neurodegenerative diseases or serious mental diseases that can cause cognitive impairment **Outcomes addressed:** Cognition	**Background and Purpose:** This study investigates the effect of physical activity (PA) on cognition in patients with cerebrovascular disease and explored the maximum benefit of different PA characteristics. **Methods:** Databases, such as Pubmed, Web of Science, Embase, and Cochrane Library, were searched from their inception to May 31, 2021. Standardized mean difference (SMD) and 95% confidence intervals (CIs) were calculated to generate a forest plot. In addition, subgroup analysis, moderation analysis, and regression analysis were performed to explore the possible adjustment factors. **Results:** In total, 22 studies that met the criteria were included, demonstrating data from 1,601 participants. The results indicated that PA produced a positive effect on the global cognition for patients with cerebrovascular disease (SMD: 0.20 [95% CI: 0.12–0.27]), at the same time, PA training prominently improved executive function (SMD: 0.09 [95% CI: 0.00–0.17]) and working memory (SMD: 0.25 [95% CI: 0.10–0.40]). Furthermore, patients with baseline cognitive impairment received the greater benefit of PA on cognition (SMD: 0.24 [95% CI: 0.14–0.34]) than those without cognitive impairment before intervention (SMD: 0.15 [95% CI: 0.04–0.26]). For patients in the acute stage (≤ 3 months), PA did not rescue impairment dysfunction significantly (SMD: 0.08 [95% CI: −0.04–0.21]) and remarkable cognitive gains were detected in the chronic stage of participants (>3 months) (SMD: 0.25 [95% CI: 0.16–0.35]). Moderate intensity PA showed a larger pooled effect size (SMD: 0.23 [95% CI: 0.11–0.36]) than low intensity (SMD: −0.01 [95% CI: −0.44–0.43]) and high intensity (SMD: 0.16 [95% CI: 0.03–0.29]). However, the different types, duration, and frequency of PA resulted in no differences in the improvement of cognitive

	function. Further regression analysis demonstrated that the beneficial effects of PA on cognition are negatively correlated with age ($p < 0.05$) Time post stroke led to a significant subgroup difference for standing balance ($P < 0.001$) in non-dose-matched therapy. In non-dose-matched therapy, different trunk therapy approaches had a significant effect on ADL (< 0.001), trunk function ($P < 0.001$) and standing balance (< 0.001).When participants received dose-matched therapy, analysis of subgroup differences showed that the trunk therapy approach had a significant effect on ADL ($P = 0.001$), trunk function ($P < 0.001$), arm-hand activity ($P < 0.001$), standing balance ($P = 0.002$), and leg function($P = 0.002$). **Conclusions:** This study revealed that PA can prominently improve the cognitive ability in patients with cerebrovascular diseases and strengthened the evidence that PA held promise as a widely accessible and effective non-drug therapy for vascular cognitive impairment (VCI).

AMSTAR 2 RATINGS

Author, Year	PICO[1]	A priori Methods[2]	Study Design Selection[3]	Search Strategy[4]	Study Selection[5]	Data Extraction[6]	Excluded Studies[7]	Included Studies[8]	RoB Assessment[9]	Funding Sources[10]	Statistical Methods[11]	Impact of RoB[12]	RoB Results[13]	Heterogeneity[14]	Publication Bias[15]	COI[16]	Overall Rating
Abba, 2022	Y	N	N	N	N	N	N	N	PY	N	N/A	N/A	Y	Y	N/A	Y	Critically low
Amorós-Aguilar, 2021	Y	N	N	N	Y	Y	N	PY	Y	N	N/A	N/A	Y	Y	N/A	Y	Critically low
Anjos, 2022	Y	PY	N	PY	Y	Y	N	N	N	N	N	N	Y	N	N	Y	Critically low
Barclay, 2022	N	N	N	N	N	N	N	Y	PY	N	Y	N	N	Y	N	Y	Critically low

Bressi, 2022	N	PY	N	N	Y	N	N	PY	Y	Y	N/A	N/A	N	N	N/A	Y	Critically low
Cai, 2022	Y	Y	N	N	Y	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	Critically low
Chen, 2022	Y	Y	N	N	Y	Y	N	PY	Y	N	N	Y	Y	Y	Y	Y	Critically low
Chiaramonte, 2022	Y	PY	N	N	Y	Y	N	PY	Y	N	N/A	N/A	Y	Y	N/A	Y	Critically low
Clark, 2021	Y	Y	Y	Y	N	Y	Y	PY	Y	Y	Y	N	Y	Y	Y	Y	Moderate
Cronin, 2023	Y	PY	Y	N	N	N	N	PY	PY	N	N	N	N	N	N	Y	Critically low
Giuriati, 2021	N	N	N	N	N	N	N	PY	PY	N	N	N	N	N	N	N	Critically low
Khattab, 2021	Y	PY	N	N	Y	Y	N	PY	Y	N	Y	N	N	Y	N	Y	Critically low
Lenoir, 2021	Y	N	Y	PY	Y	Y	N	PY	Y	N	N/A	N/A	Y	Y	N/A	Y	Critically low
Li, 2022	Y	N	N	N	N	Y	N	N	Y	N	N	N	N	N	N	Y	Critically low
Li, 2023	Y	PY	N	N	N	Y	N	PY	Y	N	N	N	N	N	N	Y	Critically low
Lin, 2022	Y	PY	N	PY	N	Y	N	N	Y	N	Y	N	Y	N	Y	Y	Low
Lyu, 2021	Y	Y	N	N	Y	Y	N	N	Y	Y	Y	N	Y	N	N	Y	Critically low
Mayer, 2021	N	N	N	N	N	Y	N	N	PY	N	N/A	N/A	Y	N	N/A	Y	Critically low
Nindorera, 2022	Y	Y	N	N	Y	Y	N	PY	Y	N	Y	Y	N	N	N	Y	Critically low
Perez-Rodriguez, 2022	N	PY	N	PY	Y	N	N	N	Y	N	N	N	N	Y	N	Y	Critically low
Postol, 2019	Y	PY	N	N	N	N	N	PY	PY	N	N	N	Y	N	N	N	Critically low
Rintala, 2022	Y	N	N	N	Y	N	N	Y	PY	N	N/A	N/A	N	Y	N/A	Y	Critically low

Saquetto, 2019	Y	N	N	PY	Y	Y	N	N	PY	N	N	N	N	N	N	Y	Critically low
Saunders, 2020	Y	PY	N	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	Y	Y	Low
Shu, 2020	Y	N	N	N	N	N	N	PY	Y	N	N	N	N	N	N	Y	Critically low
Sun, 2021	Y	PY	N	N	Y	N	N	N	Y	N	N	N	Y	N	N	Y	Critically low
Tai, 2022	N	PY	N	N	Y	Y	N	PY	Y	N	N/A	N/A	Y	Y	N/A	Y	Critically low
Thijs, 2023	Y	Y	N	Y	Y	Y	Y	PY	Y	Y	Y	Y	Y	Y	Y	Y	High
Veldema, 2020 (RT)	Y	N	N	N	Y	N	N	PY	PY	N	N	N	Y	Y	N	Y	Critically low
Veldema, 2020 (AT)	N	N	N	N	N	N	N	PY	PY	N	N	N	N	N	N	N	Critically low
Veldema, 2021	Y	N	N	N	N	N	N	PY	PY	N	N	N	Y	Y	N	Y	Critically low
Walter, 2022	N	N	N	N	N	N	N	N	Y	N	N/A	N/A	N	Y	N/A	Y	Critically low
Zhang, 2023	Y	PY	Y	N	Y	Y	N	PY	Y	N	N	N	Y	N	Y	Y	Critically low
Zheng, 2021	Y	Y	N	PY	Y	Y	N	PY	Y	Y	N	N	Y	N	N	Y	Critically low
Zhou, 2022	N	PY	N	N	Y	Y	N	PY	Y	N	Y	N	Y	Y	Y	Y	Critically low

PICO, Participant, Intervention, Comparator, Outcome; ROB, Risk of Bias; COI, Conflict of Interest; Y, Yes; N, No; PY, Partially Yes; N/A, Not Applicable.

[1] Did the research questions and inclusion criteria for the review include the components of PICO?
[2] Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?
[3] Did the review authors explain their selection of the study designs for inclusion in the review?
[4] Did the review authors use a comprehensive literature search strategy?
[5] Did the review authors perform study selection in duplicate?
[6] Did the review authors perform data extraction in duplicate?
[7] Did the review authors provide a list of excluded studies and justify the exclusions?
[8] Did the review authors describe the included studies in adequate detail?
[9] Did the review authors use a satisfactory technique for assessing the RoB in individual studies that were included in the review?
[10] Did the review authors report on the sources of funding for the studies included in the review?

[11] If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?

[12] If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?

[13] Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?

[14] Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?

[15] If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?

[16] Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

Appendix 3: Systematic Review Search Strategy

Search Dates

Ovid CENTRAL- 1991 to December 24th, 2022
Ovid MEDLINE- 1946 to December 24th, 2022
EBSCO SPORTDiscus - searched December 24th, 2022

CENTRAL

1. exp Craniocerebral Trauma/
2. Craniocerebral Trauma*.mp.
3. exp Brain Injuries, Traumatic/
4. exp Diffuse Axonal Injury/
5. diffus* axonal injur*.mp.
6. exp Brain Injuries, Diffuse/
7. ((head or crani* or capitis or brain* or forebrain* or skull* or hemisphere or intracran* or orbit* or cerebr*) adj1 (injur* or trauma* or lesion* or damage* or wound* or destruction* or oedema* or edema* or fracture* or contusion* or commotion* or pressur*)).ti,ab,kw.
8. Diffus* brain injur*.mp.
9. TBI.ti,ab,kw.
10. exp Brain Injuries/
11. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12. exp Exercise/
13. Exercis*.mp.
14. Physical activit*.mp.
15. exp Exercise Therapy/
16. exp Physical Fitness/
17. Physical fitness*.mp.
18. exp Sports/
19. Sport*.mp.
20. exp Physical Exertion/
21. physical exertion.mp.
22. exp Physical Therapy Modalities/
23. Physical therap*.mp.
24. exp Resistance Training/
25. Resistance train*.mp.
26. Physiotherap*.mp.
27. ((exercis* or circuit or aerobic or cardio* or musc* or weight* or strength* or resistance or balance or endurance or treadmill or motor* or power* or task* or mobility or gait or fitness or physical*) adj1 (therap* or train* or retrain* or program* or intervention* or protocol* or activit* or regim* or group* or class*)).tw,ti,ab.
28. (Baseball or Basketball or Bicycl* or Boxing or Football or Golf or Gymnastics or Hockey or dance* or racquet Sport* or cricket* or team sport* or run* or skat* or snow sport* or soccer* or swim* or mountain bik* or AFL or alpine ski* or archery or athletic* or badminton or basketball or biathlon or biking or Boxing or canoe* or cricket or cross country ski* or curling or cycl* or diving or duathlon or equestrian or fencing or football or golf or gymnastics or Handball or hippotherapy or Hockey or horseback riding or horse riding or judo or kayak or kickboxing or lawn bowls or bowling or marathon or netball or badminton or snowboard or triathlon or Polo or powerlifting or rowing or sailing or shooting or skiing or snowboard or soccer or surfing or table tennis or taekwondo or Tae Kwon Do or tenpin bowling or Tennis or

Trampolin* or triathlon or volleyball or volley or australian football or baseball or fencing or racing or rugby or sport* or tennis or union or league or Yoga or Tai chi or Tai ji or Chi kung or Qiqong or stretching).tw,ti,ab.

29. exp Water Sports/
30. exp Racquet Sports/
31. exp Snow Sports/
32. exp Team Sports/
33. exp Return to Sport/
34. return to sport.mp.
35. 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 or 34
36. 11 and 35
37. exp Placebos/
38. Random Assignment*.mp.
39. control groups/
40. cross-over studies/
41. (crossover or cross-over or cross over).tw.
42. (random* or placebo* or "clinical trial*").mp.
43. ((singl* or doubl* or trebl* or tripl*) adj1 (blind* or mask*)).ab,ti.
44. Systematic review*.mp.
45. exp Randomized Controlled Trials as Topic/
46. (randomized controlled trial or controlled clinical trial or placebo*).tw,pt.
47. exp Cohort Studies/
48. evaluation studies as topic/ or feasibility studies/ or pilot projects.mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
49. ((control and group*) or study or cohort or comparative stud*or evaluation studies).mp.
50. comparative study/ or meta-analysis/
51. (comparative stud* or meta-analysis*).mp.
52. 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
53. 36 and 52
54. 53 and "Humans".sa_suba.

MEDLINE

1. exp Craniocerebral Trauma/
2. Craniocerebral Trauma*.mp.
3. exp Brain Injuries, Traumatic/
4. exp Diffuse Axonal Injury/
5. diffus* axonal injur*.mp.
6. exp Brain Injuries, Diffuse/
7. ((head or crani* or capitis or brain* or forebrain* or skull* or hemisphere or intracran* or orbit* or cerebr*) adj1 (injur* or trauma* or lesion* or damage* or wound* or destruction* or oedema* or edema* or fracture* or contusion* or commotion* or pressur*)).ti,ab,kw.
8. Diffus* brain injur*.mp.
9. TBI.ti,ab,kw.

10. exp Brain Injuries/
11. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12. exp Exercise/
13. Exercis*.mp.
14. Physical activit*.mp.
15. exp Exercise Therapy/
16. exp Physical Fitness/
17. Physical fitness*.mp.
18. exp Sports/
19. Sport*.mp.
20. exp Physical Exertion/
21. physical exertion.mp.
22. exp Physical Therapy Modalities/
23. Physical therap*.mp.
24. exp Resistance Training/
25. Resistance train*.mp.
26. Physiotherap*.mp.
27. ((exercis* or circuit or aerobic or cardio* or musc* or weight* or strength* or resistance or balance or endurance or treadmill or motor* or power* or task* or mobility or gait or fitness or physical*) adj1 (therap* or train* or retrain* or program* or intervention* or protocol* or activit* or regim* or group* or class*)).tw,ti,ab.
28. (Baseball or Basketball or Bicycl* or Boxing or Football or Golf or Gymnastics or Hockey or dance* or racquet Sport* or cricket* or team sport* or run* or skat* or snow sport* or soccer* or swim* or mountain bik* or AFL or alpine ski* or archery or athletic* or badminton or basketball or biathlon or biking or Boxing or canoe* or cricket or cross country ski* or curling or cycl* or diving or duathlon or equestrian or fencing or football or golf or gymnastics or Handball or hippotherapy or Hockey or horseback riding or horse riding or judo or kayak or kickboxing or lawn bowls or bowling or marathon or netball or badminton or snowboard or triathlon or Polo or powerlifting or rowing or sailing or shooting or skiing or snowboard or soccer or surfing or table tennis or taekwondo or Tae Kwon Do or tenpin bowling or Tennis or Trampolin* or triathlon or volleyball or volley or australian football or baseball or fencing or racing or rugby or sport* or tennis or union or league or Yoga or Tai chi or Tai ji or Chi kung or Qiqong or stretching).tw,ti,ab.
29. exp Water Sports/
30. exp Racquet Sports/
31. exp Snow Sports/
32. exp Team Sports/
33. exp Return to Sport/
34. return to sport.mp.
35. 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 or 34
36. 11 and 35
37. exp Placebos/
38. Random Assignment*.mp.
39. control groups/
40. cross-over studies/
41. (crossover or cross-over or cross over).tw.
42. (random* or placebo* or "clinical trial*").mp.

43. ((singl* or doubl* or trebl* or tripl*) adj1 (blind* or mask*)).ab,ti.
44. Systematic review*.mp.
45. exp Randomized Controlled Trials as Topic/
46. (randomized controlled trial or controlled clinical trial or placebo*).tw,pt.
47. exp Cohort Studies/
48. evaluation studies as topic/ or feasibility studies/ or pilot projects.mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
49. ((control and group*) or study or cohort or comparative stud*or evaluation studies).mp.
50. comparative study/ or meta-analysis/
51. (comparative stud* or meta-analysis*).mp.
52. 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
53. 36 and 52
54. 53 and "Humans".sa_suba.

SPORTDiscus

S1 "BRAIN damage" OR "BRAIN injuries" OR "BRAIN damage" OR "CHRONIC traumatic encephalopathy"

S2 "diffus* axonal injur*"

S3 "diffus* brain injur*"

S4 ((“head” OR “crani*” OR “capitis” or “brain*” OR “forebrain*” OR “skull*” OR “hemisphere” OR “intracran*” OR “orbit*” OR “cerebr*”) N1 (“injur*” OR “trauma*” OR “lesion*” or “damage*” OR “wound*” OR “destruction*” OR “oedema*” OR “edema*” OR “fracture*” OR “contusion*” OR “commotion*” OR “pressur*”))

S5 TI "TBI" OR AB "TBI"

S6 S1 OR S2 OR S3 OR S4 OR S5

S7 exercis*

S8 "Physical activit*"

S9 "exercise therap*"

S10 "physical fitness"

S11 Sport*

S12 “recreational therap*”

S13 "Resistance train*"

S14 ((“exercis*” OR “circuit” OR “aerobic” OR “cardio*” OR “musc*” OR “weight*” OR “strength*” OR “resistance” OR “balance” OR “endurance” OR “treadmill” OR “motor*” OR “power*” OR “task*” OR “mobility” OR “gait” OR “fitness” OR “physical*”) N1 (“therap*” OR “train*” OR “retrain*” OR “program*” OR “intervention*” OR “protocol*” OR “activit*” OR “regim*” OR “group*” OR “class*”))

S15 "physiotherap*"

S16 (“Baseball” OR “Basketball” OR “Bicycl*” OR “Boxing” OR “Football” OR “Golf” OR “Gymnastics” OR “Hockey” OR “dance*” OR “racquet Sport*” OR “cricket*” OR “team sport*” OR “run*” OR “skat*” OR “snow sport*” OR “soccer*” OR “swim*” OR “mountain bik*” OR “AFL” OR “alpine ski*” OR “archery” OR “athletic*” OR “badminton” OR “basketball” OR “biathlon” OR “biking” OR “Boxing” OR “canoe*” OR “cricket” OR “cross country ski*” OR “curling” OR “cycl*” OR “diving” OR “duathlon” OR “equestrian” OR “fencing” OR “football”

OR “golf” OR “gymnastics” OR “Handball” OR “hippotherapy” OR “Hockey” OR “horseback riding” OR “horse riding” OR “judo” OR “kayak” OR “kickboxing” OR “lawn bowls” OR “bowling” OR “marathon” OR “netball” OR “badminton” OR “snowboard” OR “triathlon” OR “Polo” OR “powerlifting” OR “rowing” OR “sailing” OR “shooting” OR “skiing” OR “snowboard*” OR “soccer” OR “surfing” OR “table tennis” OR “taekwondo” OR “Tae Kwon Do” OR “tenpin bowling” OR “Tennis” OR “Trampolin*” OR “triathlon” OR “volleyball” OR “volley” OR “australian football” OR “baseball” OR “fencing” OR “racing” OR “rugby” OR “sport*” OR “tennis” OR “union “OR “league” OR “Yoga” OR “Tai chi” OR “Tai ji” OR “Chi kung” OR “Qiqong” OR “stretching” or "team sport* or "ball game*" or "Aquatic sport*" or "water sport*" or "racquet sport*" or "snow sport*" or "team sport*" or "return to sport*")

S17 hydrotherap*

S18 S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17

S19 TI ((("singl*" OR "doubl*" OR "trebl*" OR "tripl*") N1 ("blind*" OR "mask*"))) OR AB ((("singl*" OR "doubl*" OR "trebl*" OR "tripl*") N1 ("blind*" OR "mask*")))

S20 TI (("Systematic review*" OR AB "Systematic review*")) OR AB ((TI "Systematic review*" OR AB "Systematic review*"))

S21 TI ("randomized controlled trial" OR "controlled clinical trial" OR "placebo*") OR AB ("randomized controlled trial" OR "controlled clinical trial" OR "placebo*")

S22 TI (meta-analys* OR metaanalys* OR meta analys*) OR AB (meta-analys* OR metaanalys* OR meta analys*)

S23 "controlled trial" OR "clinical trial" or random* or "random sampling" or "clinical trial* or "crossover" OR "crossover" OR "cross over"

S24 "feasibility stud*" OR "pilot project" OR "pilot stud*" OR ("control and group") OR "cohort stud*" OR "comparative stud*"

S25 S19 OR S20 OR S21 OR S22 OR S23 OR S24

S26 S6 AND S18 AND S25

Appendix 4: BRIDGES brain injury rehabilitation service audit survey

Service Audit Questions

Thank you for agreeing to participate in this survey regarding current practice in moderate-to-severe traumatic brain injury (TBI) rehabilitation.

Our research aims to develop clinical practice guidelines to support people living with a moderate-to-severe TBI to be physically active and therefore, healthier. These guidelines will play a role in developing evidence-based services and funding recommendations, and they will help health professionals to make referrals that are right for their patients. To make sure the guidelines are appropriate for the Australian context, we need to first understand current practice, and identify gaps, inconsistencies and/or differences in services across Australia.

Your participation in this process will help to inform our understanding of current practice and assist us in developing and implementing clinical practice guidelines in the future. In this questionnaire, patient refers to people with moderate-to-severe TBI. Moderate-to-severe TBI is defined as an injury to the brain caused by an external force (e.g., motor vehicle accident, fall, assault) with a period of post-traumatic amnesia ≥ one day and/or an altered level of consciousness (Glasgow Coma Scale ≤ 12) or loss of consciousness ≥ 30 minutes post-trauma. Concussion/Mild TBI are not included in this study.

There are three parts to this survey. It should take approximately 45-60 minutes to complete.

- Part 1: Asks you to describe the make-up of the service you currently work in.
- Part 2: Comprises of 7 sections looking at the provision and promotion of different types of physical activity at your service including:
    - Aerobic training
    - Lower extremity strength training
    - Gait/balance/functional training (mobility)
    - Multicomponent training
    - Sport and physical recreation
    - Unstructured play, recreation, or functional training with children
    - Promotion of physical activity
- Part 3: Asks you to share with the research team (by uploading or providing a link) any relevant resources.

Part 1: Service description

1. What type is your rehabilitation service?
    a. Specialist brain injury rehabilitation service (within hospital system)
    b. Non-specialist rehabilitation service (within hospital system)
    c. Outpatient or domiciliary rehabilitation private practice
    d. Other_______

2. How is your service funded?
    a. Private
    b. Public
    c. Mixed

3. Which state/territory of Australia is your service located?

a. New South Wales
b. Victoria
c. Queensland
d. Tasmania
e. Australian Capital Territory
f. Northern Territory
g. South Australia
h. Western Australia

4. What is the location of your service within your state/territory?
    a. Major city
    b. Inner regional
    c. Outer regional or remote

5. What age group of patients/clients does your service manage? (select all relevant)
    a. Children (0 - 12 years of age)
    b. Adolescents (13 – 17 years of age)
    c. Working age adults (15 – 65 years of age)
    d. Older adults (65 +)

6. How many staff are there in your service working with people with moderate-to-severe TBI who may be involved in promoting and/or delivering physical activity?

Staff Type	**Actual Number**
Rehabilitation Specialists	
Physiotherapists	
Exercise Physiologists	
Allied Health Assistants working with Physiotherapists and Exercise Physiologists	
Occupational Therapists	
Sport and Recreation Officers	
Clinical Psychologists	
Case Managers	
Other staff who deliver and/or promote physical activity	

7. Does your service include the following components? (Please select all that apply)
    a. Inpatient or in-reach rehabilitation
        i. Number of moderate-to-severe TBI patients new to the inpatient or in-reach service in 2021.
    b. Transitional living unit
        i. Number of moderate-to-severe TBI patients new to the transitional living unit service in 2021.
    c. Outpatient/Community rehabilitation
        i. Number of moderate-to-severe TBI patients new to the community service in 2021.

Part 2: Provision and promotion of physical activity within your service

Physical activity is defined as any activity involving "bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen et al., 1985). This includes:

- Structured exercise- aerobic training
- Structured exercise- lower extremity strength training
- Structured exercise- gait/balance/functional training
- Multicomponent training (combination of two or more of the above exercise types)
- Sport and physical recreation
- Unstructured play, recreation, or functional training with children
- Promotion of overall physical activity (e.g., health coaching, pedometer programs).

For each of the above categories, we want to understand if they are routinely provided as part of your service.

Aerobic training:

1. Is aerobic training delivered in your setting? Y/N

(*via branching logic, if No, only complete Q9 of this section*)

2. Who prescribes or delivers it? (Select all that apply)
   a. Physiotherapist
   b. Exercise Physiologist
   c. Other (please specify)

3. How is it delivered?

Of the patients who are eligible to train with the modes listed below, please indicate what percentage use that mode in your practice (note the total percentage does not need to sum to 100% as we want you to consider each mode you have in your service and indicate what percentage of eligible/suitable patients would use it).

	% eligible patients trained
Treadmill	
Cross trainer	
Cycle ergometry	
Arm ergometry	
Motomed	
Circuit class	
Stepper	
Recumbent Stepper (e.g., NuStep)	
Other (free text)	

4. Do you conduct an aerobic fitness test (e.g. submaximal or maximal treadmill test) to set training parameters? Y/N
   a. Do you use a protocol to test aerobic fitness? Y/N
      i. If yes, what protocol(s) do you use (e.g., Bruce treadmill test protocol)?
      ii. If no, can you describe how you test aerobic fitness?
   b. If yes to 4, what equipment is required to conduct the fitness test?

5. What is the typical intensity that aerobic training is prescribed (e.g., 60-80% of HRmax, 40-85%HRR, rating of perceived exertion)?
   a. (Free text response)
   b. Is the intensity of training monitored? Y/N
   c. If yes, how?

6. What is the typical duration of aerobic training within a training session? (mins)

7. What is the typical frequency of (days per week)
   a. Supervised aerobic training
   b. Unsupervised aerobic training

8. In addition to the equipment mentioned in question 3 above, what other equipment do you use to support aerobic fitness training? (Select all relevant)
   a. Heart rate monitor
   b. Harness over treadmill
   c. Virtual reality
   d. Other (free text)

9. Do you refer your patients/clients to someone else outside of your service for aerobic training? Y/N
   a. If yes, what type of professional? (free text)

10. Do you train family/support workers to supervise aerobic training programs?
   a. No
   b. Yes
      i. Always
      ii. Frequently
      iii. Sometimes
      iv. Infrequently

11. Are there any barriers that limit your service's ability to deliver or refer to aerobic training? (Select all that apply and use the box that appears to elaborate or provide any comments)
   a. Knowledge
   b. Skills
   c. Beliefs around intervention
   d. Not a priority
   e. Habits
   f. Resources
   g. Time
   h. Not common practice
   i. Safety
   j. Other (please specify)

Lower Extremity Strength training:

1. Is lower extremity strength training delivered in your setting? Y/N (If No, *only complete Q9 of this section*)
   a. For very weak muscles (Manual Muscle Test (MMT) 1-2) Y/N
   b. For weak muscles (MMT 3-4) Y/N

2. Who prescribes or delivers it? (Select all that apply)
    a. Physiotherapist
    b. Exercise Physiologist
    c. Other (please specify)

3. Do you assess muscle strength to set training parameters? Y/N
    a. If yes, what test/outcome measure do you use?
    b. If yes, what equipment is required to assess muscle strength?

4. How is it delivered for <u>very weak</u> muscles (i.e., MMT 1-2)? (% of eligible patients that would be trained with different modes)
    a. Reducing friction (e.g. slideboards or pulleys)
    b. Electrical stimulation
    c. EMG biofeedback
    d. Manual guidance
    e. Hydrotherapy
    f. Other (please specify)

5. How is it delivered for <u>weak</u> muscles (i.e., MMT 3-4)? (% of eligible patients that would be trained with different modes)
    a. Progressive resistive strength training
    b. Ballistic strength training
    c. General strength training
    d. EMG biofeedback
    e. Hydrotherapy
    f. Other (please specify)

6. What typical training parameters (repetitions/sets/frequency) do you prescribe for strengthening <u>very weak</u> muscles (i.e., MMT 1-2)?

7. What typical training parameters (repetitions/sets/frequency) do you prescribe for strengthening <u>weak</u> muscles (i.e., MMT 3-4)?

8. What other equipment do you use to support strength training? (Select all relevant)
    a. Suspension slings and springs
    b. Hand held weight
    c. Cuff weights
    d. Weighted vest
    e. Weight machines
    f. Jump trainer
    g. Tilt-table
    h. Other (free text)

9. Do you refer your patients/clients to someone else outside of your service for strength training? Y/N
    a. If yes, what type of professional? (free text)

10. Do you train family/support workers to supervise strength training programs?
    a. No
    b. Yes

i. Always
ii. Frequently
iii. Sometimes
iv. Infrequently

11. Are there any barriers that limit your service's ability to deliver or refer to strength training? (Select all that apply and use the box that appears to elaborate or provide any comments)
   a. Knowledge
   b. Skills
   c. Beliefs around intervention
   d. Not a priority
   e. Habits
   f. Resources
   g. Time
   h. Not common practice
   i. Safety
   j. Other (please specify)

Gait/balance/functional training (mobility):

1. Is functional training to improve mobility delivered in your setting? Y/N (If No, *only complete Q5 of this section*)
   a. Bed mobility
   b. Standing up from sitting
   c. Balancing in standing
   d. Walking
   e. Stair climbing
   f. Running
   g. Other (please specify)

2. Who prescribes or delivers it? (Select all that apply)
   a. Physiotherapist
   b. Exercise Physiologist
   c. Other (please specify)

3. What outcome measure(s) do you *routinely* use to measure mobility?
   a. 10 MWT
   b. 6MWT
   c. Short Physical Performance Battery
   d. 5x sit to stand
   e. Timed standing balance
   f. HiMAT
   g. 20/40/50m run test
   h. Berg Balance Scale
   i. Motor Assessment Scale
   j. TUG
   k. Functional Reach Test
   l. Other (please specify)

4. What equipment do you use to support mobility training? (Select all relevant)

a. Up/down plinth
b. Walking track
c. Treadmill
d. Bodyweight support harness
e. Robotics
f. Virtual reality
g. Stairs
h. Trampette/mini-trampoline
i. Walking frame
j. Walking stick
k. Ankle-foot orthoses
l. Transfer belt
m. Other (free text)

5. Do you refer your patients/clients to someone else outside of your service for mobility training? Y/N
    a. If yes, what type of professional? (free text)

6. Do you train family/support workers to supervise mobility training programs?
    a. No
    b. Yes
        i. Always
        ii. Frequently
        iii. Sometimes
        iv. Infrequently

7. Are there any barriers that limit your service's ability to deliver or refer to mobility training? (Select all that apply and use the box that appears to elaborate or provide any comments)
    a. Knowledge
    b. Skills
    c. Beliefs around intervention
    d. Not a priority
    e. Habits
    f. Resources
    g. Time
    h. Not common practice
    i. Safety
    j. Other (please specify)

Multicomponent training:

1. Do you deliver any **group-based** interventions that would target two or more of the above types of physical activity (i.e. fitness, strength, mobility) Y/N (If No, skip to sport and physical recreation)

If yes, describe the…

    a. Type of group-based program
        i. Circuit class
        ii. Individually tailored program in group setting
        iii. Other (specify)

b. Focus of Training program (i.e., strength & fitness, mobility & fitness, etc) (free text)
c. Frequency of the group
d. Duration of the group
e. Average number of attendees
f. Supervision ratio (staff to patient/client)
g. Manner in which patients/clients are supervised (i.e., rating of perceived exertion, set times on equipment, devices used, etc) (free text)

2. Are there any barriers that limit your service's ability to deliver or refer to multicomponent training? (Select all that apply and use the box that appears to elaborate or provide any comments)
a. Knowledge
b. Skills
c. Beliefs around intervention
d. Not a priority
e. Habits
f. Resources
g. Time
h. Not common practice
i. Safety
j. Other (please specify)

Sport and physical recreation:

Sport is defined *as "an activity involving physical exertion, skill and/or hand-eye coordination as the primary focus of the activity, with elements of competition where rules and patterns of behaviour governing the activity exist formally through organisations" (ABS, 2008).*

Physical recreation is defined as "*an activity or experience that involves varying levels of physical exertion, prowess and/or skill, which may not be the main focus of the activity and is voluntarily engaged in by an individual in leisure time for the purpose of mental and/or physical satisfaction" (ABS, 2008)*.

1. Is sport and/or physical recreation delivered in your setting? Y/N (If No, *only complete Q7 of this section*)

2. If yes, describe what is delivered (free text).

3. Who prescribes or delivers it? (Select all that apply)
a. Physiotherapist
b. Exercise Physiologist
c. Sport and Recreation Officer
d. Other (please specify)

4. Frequency of delivery
a. ≥ 1x per week
b. 1-3x per month
c. 1-2x per 3 months
d. 1-2x per 6 months
e. 1x per 12 months

f. No set timing

5. Does your service link with external services/providers to deliver sport and/or physical recreation activities? If yes, who.

6. Does your service have any equipment to support provision of sport and/or recreation activities? If yes, what.

7. Does your service refer your patients/clients to a:

	Always	Frequently	Sometimes	Infrequently	Never
Community-based fitness centre					
	◯	◯	◯	◯	◯
Community based-physical recreation group (e.g. exercise group, yoga, tai chi, dance, walking group)					
Acquired brain injury specific	◯	◯	◯	◯	◯
Disability/Chronic disease specific	◯	◯	◯	◯	◯
Integrated disability and mainstream	◯	◯	◯	◯	◯
Mainstream	◯	◯	◯	◯	◯
Community based sporting organisation/competition (e.g., cricket, football, netball, tennis)					
Acquired brain injury specific	◯	◯	◯	◯	◯
Disability/Chronic disease specific	◯	◯	◯	◯	◯
Integrated disability and mainstream	◯	◯	◯	◯	◯
Mainstream	◯	◯	◯	◯	◯

8. Are there any barriers that limit your service's ability to deliver or refer to sport/physical recreation activities? (Select all that apply and use the box that appears to elaborate or provide any comments)

a. Knowledge
b. Skills
c. Beliefs around intervention
d. Not a priority
e. Habits
f. Resources
g. Time
h. Not common practice
i. Safety
j. Other (please specify)

Unstructured play, recreation, or functional training with children:

1. Do you deliver any unstructured play, recreation, or functional training to children? Y/N

If yes, describe the…

   a. Type of unstructured play, recreation, or functional training
      i. Group training
      ii. Individual training
      iii. Other (specify)
   b. Focus of Training program (i.e., strength & fitness, mobility & fitness, etc) (free text)
   c. Frequency of the training
   d. Duration of the training
   e. Manner in which patients/clients are supervised (i.e., rating of perceived exertion, set times on equipment, devices used, parental supervision) (free text)

2. Are there any barriers that limit your service's ability to deliver or refer to this type of training? (Select all that apply and use the box that appears to elaborate or provide any comments)
   a. Knowledge
   b. Skills
   c. Beliefs around intervention
   d. Not a priority
   e. Habits
   f. Resources
   g. Time
   h. Not common practice
   i. Safety
   j. Other (please specify)

Promotion of physical activity:

1. Is it standard practice in your service to assess pre-injury physical activity to determine:
   a. If the person was meeting physical activity guidelines? Y/N If yes, how
      i. Standardized questionnaire (specify) (y/n)
      ii. Part of history taking (y/n)
   b. The types of activities they participated in. Y/N If yes, how
      i. Standardized questionnaire (specify) (y/n)
      ii. Part of history taking (y/n)

2. Is it standard practice in your service to assess current physical activity levels in?
   a. Inpatient setting. Y/N If yes, how
      i. Device-based measure (if yes, which device) (y/n)
      ii. Observation (y/n)
   b. Transitional care setting. Y/N If yes, how
      i. Device-based measure (if yes, which device) (y/n)
      ii. Standardized questionnaire (specify) (y/n)
      iii. Part of history taking (y/n)
   c. Outpatient/Community/School setting. Y/N If yes, how
      i. Device-based measure (if yes, which device) (y/n)
      ii. Standardized questionnaire (specify) (y/n)
      iii. Part of history taking (y/n)

3. Is it standard practice in your service to provide advice about?
    a. Benefits of physical activity Y/N
    b. Physical activity guidelines Y/N
    c. Type and dosage of physical activity Y/N

4. Is it standard practice in your service to collaboratively develop a long-term physical activity goal(s) with your patients/clients? (Y/N) (options based on branching logic from Part 1, question 7)
    a. Inpatient setting
    b. Transitional living setting
    c. Outpatient/community setting

5. Who is involved in developing these goals? (Select all that apply)
    a. Patient
    b. Staff
    c. Family
    d. Carers
    e. Other (please specify)

6. Is it standard practice in your service to provide interventions, such as motivational interviewing/health coaching/behaviour change counselling, to work with your patients/clients to change their physical activity behaviour?
    a. No
    b. Yes
        i. Always
        ii. Frequently
        iii. Sometimes
        iv. Infrequently

7. How many of the staff who would promote physical activity to patients/clients have had training in motivational interviewing/health coaching/behaviour change?

	Number of staff (as indicated in Part 1)	% of staff with training in motivational interviewing/health coaching/behaviour change
Rehabilitation Specialists	(auto-populated from Part 1, Q6)	
Physiotherapists	(auto-populated from Part 1, Q6)	
Exercise Physiologists	(auto-populated from Part 1, Q6)	
Allied Health Assistants working with Physiotherapists and Exercise Physiologists	(auto-populated from Part 1, Q6)	
Occupational Therapists	(auto-populated from Part 1, Q6)	
Sport and Recreation Officers	(auto-populated from Part 1, Q6)	
Clinical Psychologists	(auto-populated from Part 1, Q6)	
Case Managers	(auto-populated from Part 1, Q6)	
Other staff who deliver and/or promote physical activity	(auto-populated from Part 1, Q6)	

8. Are there any barriers that limit your service's ability to provide physical activity promotion interventions? (Select all that apply and use the box that appears to elaborate or provide any comments)

a. Knowledge
b. Skills
c. Beliefs around intervention
d. Not a priority
e. Habits
f. Resources
g. Time
h. Not common practice
i. Safety
j. Other (please specify)

Part 3: Sharing resources

As part of this project, we are looking at developing a national repository of physical activity resources for health professionals working with people with moderate-to-severe TBI.

a. Do you have any digital or paper-based resources from your service that you are willing to share with this project (e.g., fitness, strength, mobility training policies/procedures/protocols)? [Note, origin of any resources used within this project will be acknowledged]

[upload document(s) option]

Do you have any comments about your digital or paper-based resources? (free text box)

b. Do you use any online resources that you can provide links to?

[free text box for links]

Do you have any comments about the online resources you use? (free text box)

Thank you for your contributions to this study! If you have any questions or concerns regarding this project, please contact:
Leanne Hassett on leanne.hassett@sydney.edu.au
Gavin Williams on gavin.williams@epworth.org.au
Liam Johnson on liam.johnson@acu.edu.au

***The Guideline development group wishes to acknowledge the following site champions who facilitated the collection of audit data: Tristan Clements, Nikki Cooke, Tom Cordner, Tom Dibdin, Gia Di Marco, Domenic Denichilo, Joanna Elizalde, Gay Florentino, Karen Foreman, Vivienne Forrest, Anna Hahn, Jessica Johnston, Johnny Leung, Erika Lori, Simon Mills, Kylie Milward, Kavya Pilli, Dawn Prasad, Jemima Readford, Sania Salim, Kirrilee Smith, Sarah Tan, Bridget Sticpewich, Bronwyn Thomas, Megan Thorburn, Belinda Wang, and Gavin Williams.**

Appendix 5: Guideline development meetings

Guideline Development Meetings - Attendance

July 20th 2023

1. Nicholas Waters
2. Joanne Glinksky
3. Kieran Witts
4. Julie Witts
5. Sakina Chagpar
6. Liam Johnson
7. Leanne Hassett
8. Gabrielle Vassallo
9. Francesca Brady
10. Sarah Veli-Gold
11. Bhavini Whiteside
12. Tim
13. Abby Haynes
14. Belinda Wang
15. Gavin Williams
16. Zachary Munn
17. Olivia Beattie
18. Domenic Denichilo
19. Sania Salim
20. Alexandra Edmonson
21. Kerry West
22. Grahame Simpson
23. Anthony Mamo
24. Sean Tweedy
25. Peter Mayhew
26. Kate Heine
27. Nick Rushworth
28. Rhys Ashpole
29. Kelly Clanchy
30. Sonia Hoppe
31. Ben Sammut
32. Adam Scheinberg

July 21st 2023

1. Grahame Simpson
2. Olivia Beattie
3. Gavin Williams
4. Sakina Chagpar
5. Nicholas Waters
6. Peter Mayhew
7. Kerry West
8. Adam Scheinberg
9. Kate Heine
10. Leanne Hassett
11. Bhavini Whiteside

12. Francesca Brady
13. Abby Haynes
14. Sean Tweedy
15. Kelly Clanchy
16. Anthony Mamo
17. Liam Johnson
18. Kieran Witts
19. Julie Witts
20. Domenic Denichilo
21. Rhys Ashpole
22. Sania Salim
23. Gabrielle Vassallo
24. Adrian Bauman
25. Sarah Veli-Gold
26. Joanne Glinsky

July 28th 2023

1. Liam Johnson
2. Sakina Chagpar
3. Gabrielle Vassallo
4. Francesca Brady
5. Sarah Veli-Gold
6. Joanne Glinksy
7. Leanne Hassett
8. Gavin Williams
9. Domenic Domenchilo
10. Kelly Clanchy
11. Adam Scheinberg
12. Alexandra Edmonson
13. Kate Heine
14. Kerry West
15. Sania Salim
16. Grahame Simpson

August 4th 2023

1. Kieran Witts
2. Julie Witts
3. Anthony Mamo
4. Leanne Hassett
5. Joanne Glinsky
6. Francesca Brady
7. Rhys Ashpole
8. Liam Johnson
9. Anne Tiedemann
10. Gabrielle Vassallo
11. Nicholas Waters
12. Adam Scheinberg
13. Kerry West
14. Sakina Chagpar
15. Domenic Domenchilo

16. Grahame Simpson
17. Kelly Clanchy

August 7th 2023

1. Julie Witts
2. Benjamin Sammut
3. Anthony Mamo
4. Sakina Chagpar
5. Gabrielle Vassallo
6. Leanne Hassett
7. Liam Johnson
8. Joanne Glinksky
9. Gavin Williams
10. Abby Haynes
11. Sarah Veli-Gold
12. Kerry West
13. Kelly Clanchy
14. Alexandra Edmonson
15. Adam Scheinberg
16. Rhys Ashpole
17. Bhavini Whiteside
18. Sean Tweedy

Guideline Development Meetings – Voting Records

Clinical question 1: Conditional Recommendation

For adults after moderate to severe traumatic brain injury (TBI) who have reduced aerobic fitness, rehabilitation may include individually-tailored exercise interventions following training principles to improve cardiorespiratory fitness.

For long-term health benefits, adults after moderate to severe TBI can be recommended to participate in regular aerobic physical activity regardless of their level of disability. Recommendation can be based on the WHO physical activity guidelines for adults living with a disability (Carty, 2021).

Changed to: Conditional Recommendation

For adults and older adults after moderate to severe traumatic brain injury we suggest regular structured aerobic exercise that is individually-tailored and across the continuum of care.

Do you broadly agree with the type of recommendation?

Votes	Yes	No	Number voting	Number abstains
1	21	3	24	2

Do you agree with this recommendation?

Votes	Yes	No	Number voting	Number abstains
1	22	1	23	3

Criteria 6: Should this rating be changed? (Move from probably favours the intervention to favours the intervention):

Votes	Yes	No	Number voting	Number abstains
1	17	9	26	3

Criteria 10: Should this rating be changed? (Move from probably increased to increased):

Votes	Yes	No	Number voting	Number abstains
1	11	15	26	2

Criteria 11: Should this rating be changed? (Move from probably yes to yes):

Votes	Yes	No	Number voting	Number abstains
1	16	10	26	2

Clinical question 2: Conditional Recommendation

For children and adolescents after moderate to severe traumatic brain injury we suggest regular aerobic play or exercise that is individually tailored and across the continuum of care.

Changed to:

For children and adolescents after moderate to severe traumatic brain injury we suggest regular aerobic play and/or exercise that is individually-tailored and across the continuum of care.

Do you broadly agree with the type of recommendation?

Votes	Yes	No	Number voting	Number abstains
1	22	2	24	0

Do you agree with this recommendation?

Votes	Yes	No	Number voting	Number abstains
1	23	1	24	0

Criteria 2: Should this rating be changed? (Move from varies to small or don't know):

Votes	Yes	No	Number voting	Number abstains
1	10	14	24	0

Criteria 11: Should this rating be changed? (Move from probably yes to yes):

Votes	Yes	No	Number voting	Number abstains
1	18	5	23	0

Clinical question 3: Strong Recommendation

For adults after moderate to severe TBI, we recommend structured muscle strengthening training, including ballistic exercise training, across the continuum of care.

Change to: Strong Recommendation

For adults and older adults after moderate to severe TBI, we recommend individually-tailored structured muscle strengthening exercise, including ballistic training, across the continuum of care.

Do you broadly agree with the type of recommendation?

Votes	Yes	No	Number voting	Number abstains
1	17	4	21	3

Do you agree with this recommendation?

Votes	Yes	No	Number voting	Number abstains
1	19	3	22	3

Criteria 3: Should this rating be changed? (Move from trivial to small):

Votes	Yes	No	Number voting	Number abstains
1	8	13	22	3

Criteria 6: Should this rating be changed? (Move from probably favours the intervention to favours the intervention):

Votes	Yes	No	Number voting	Number abstains
1	17	5	22	3

Criteria 10: Should this rating be changed? (Move from probably increased the intervention to increased

Votes	Yes	No	Number voting	Number abstains
1	11	10	21	3

Criteria 11: Should this rating be changed? (Move from probably yes to yes)

Votes	Yes	No	Number voting	Number abstains
1	15	7	22	3

Criteria 12: Should this rating be changed? (Move from probably yes to yes)

Votes	Yes	No	Number voting	Number abstains
1	7	15	22	3

Clinical question 4: Conditional Recommendation

For children and adolescents after moderate to severe TBI, we suggest structured muscle strengthening training, including individually-tailored play or exercise interventions, across the continuum of care.

Changed to: Conditional Recommendation

For children and adolescents after moderate to severe TBI, we suggest regular muscle strengthening play and/or functional exercise, that is individually-tailored and across the continuum of care.

Do you broadly agree with the type of recommendation?

Votes	**Yes**	**No**	**Number voting**	**Number abstains**
1	20	0	20	3

Do you agree with this recommendation?

Votes	**Yes**	**No**	**Number voting**	**Number abstains**
1	20	0	20	3

Criteria 2: Should this rating be changed? (Move from small to something else):

Votes	**Yes**	**No**	**Number voting**	**Number abstains**
1	10	12	22	2

Criteria 11: Should this rating be changed? (Move from probably yes to yes):

Votes	**Yes**	**No**	**Number voting**	**Number abstains**
1	13	9	22	2

Clinical question 5: Strong Recommendation

For adults and older adults with mobility limitations after moderate to severe traumatic brain injury we recommend goal-directed mobility training incorporating motor learning principles (including task-specific, repetitive, and intensive practice) across the continuum of care.

Change to:

For adults and older adults after moderate to severe traumatic brain injury we recommend task-specific mobility training across the continuum of care.

Do you broadly agree with the type of recommendation?

Votes	Yes	No	Number voting	Number abstains
1	12	2	14	0

Do you agree with this recommendation?

Votes	Yes	No	Number voting	Number abstains
1	14	0	14	0

Criteria 3: Should this rating be changed? (Move from small to trivial)

Votes	Yes	No	Number voting	Number abstains
1	10	4	14	0

Criteria 4: Should this rating be changed? (Move from low to moderate)

Votes	Yes	No	Number voting	Number abstains
1	8	6	14	0

Criteria 6: Should this rating be changed? (Move from probably favours the intervention to favours the intervention) – Neuroplasticity comment in discussion

Votes	Yes	No	Number voting	Number abstains
1	12	2	14	0

Criteria 11: Should this rating be changed? (Move from probably yes to yes)

Votes	Yes	No	Number voting	Number abstains
1	14	0	14	0

Clinical question 6: Conditional Recommendation

For children and adolescents with mobility limitations after moderate to severe traumatic brain injury we suggest goal directed mobility training incorporating motor learning principles (including task-specific, repetitive, and intensive practice) across the continuum of care.

Changed to:

For children and adolescents after moderate to severe traumatic brain injury we suggest task-specific mobility training across the continuum of care.

Do you broadly agree with the type of recommendation?

Votes	Yes	No	Number voting	Number abstains
1	13	0	13	1

Do you agree with this recommendation?

Votes	Yes	No	Number voting	Number abstains
1	13	0	13	0

Criteria 3: Should this rating be changed? (Move from small to trivial)

Votes	Yes	No	Number voting	Number abstains
1	12	0	12	0

Criteria 11: Should this rating be changed? (Move from probably yes to yes)

Votes	Yes	No	Number voting	Number abstains
1	11	0	11	2

Criteria 11: Should this rating be changed? (Move from probably yes to yes)

Votes	Yes	No	Number voting	Number abstains
1	11	0	11	2

Clinical question 7: Conditional Recommendation

For adults after moderate to severe TBI, we suggest participation in sport and physical recreation.

Changed to:

For adults after moderate to severe TBI, we suggest participation in sport and physical recreation across the continuum of care considering their personal preference and capability.

Do you broadly agree with the type of recommendation?

Votes	Yes	No	Number voting	Number abstains
1	12	0	12	1

Do you agree with this recommendation?

Votes	Yes	No	Number voting	Number abstains
1	12	0	12	0

Criteria X: Should this rating be changed? (Move from varies to moderate costs)

Votes	Yes	No	Number voting	Number abstains
1	1	11	12	0

Criteria 11: Should this rating be changed? (Move from probably yes to yes)

Votes	Yes	No	Number voting	Number abstains
1	6	6	12	0
2	2	10	12	0

Clinical question 8: Conditional Recommendation

For children and adolescents after moderate to severe TBI, we suggest participation in sport and physical recreation.

Changed to: Conditional Recommendation

For children and adolescents after moderate to severe TBI, we suggest participation in sport and physical recreation across the continuum of care considering their personal preference and capability.

Do you broadly agree with the type of recommendation?:

Votes	Yes	No	Number voting	Number abstains
1	16	1	17	0

Do you agree with this recommendation?:

Votes	Yes	No	Number voting	Number abstains
1	17	0	17	0

Clinical question 9: Conditional Recommendation

For adults after moderate to severe TBI, we suggest participation in interventions that promote overall physical activity.

Changed to:

For adults after moderate to severe TBI, we suggest the promotion of physical activity across the continuum of care.

Do you broadly agree with the type of recommendation?

Votes	Yes	No	Number voting	Number abstains
1	13	1	14	2

Do you agree with this recommendation?

Votes	Yes	No	Number voting	Number abstains
1	15	0	15	1

Criteria 6: Should this rating be changed? (Move from probably favours the intervention to favors the intervention)

Votes	Yes	No	Number voting	Number abstains
1	9	6	15	1

Criteria 7: Should this rating be changed? (Move from negligible costs and savings to varies)

Votes	Yes	No	Number voting	Number abstains
1	12	2	14	2

Criteria 11: Should this rating be changed? (Move from probably yes to yes)

Votes	Yes	No	Number voting	Number abstains
1	13	2	15	1

Clinical question 10: Conditional Recommendation

For children and adolescents after moderate to severe TBI, we suggest the promotion of physical activity across the continuum of care.

Changed to:

For children and adolescents after moderate to severe TBI, we suggest the promotion of physical activity across the continuum of care.

Do you broadly agree with the type of recommendation?

Votes	Yes	No	Number voting	Number abstains
1	15	0	15	0

Do you agree with this recommendation?

Votes	Yes	No	Number voting	Number abstains
1	15	0	15	0

Criteria 2: Should this rating be changed? (Move from Moderate to Varies)

Votes	Yes	No	Number voting	Number abstains
1	2	15	17	0

Criteria 7: Should this rating be changed? (Move from Negligible costs and savings to Varies)

Votes	Yes	No	Number voting	Number abstains
1	14	1	15	1

Criteria 11: Should this rating be changed? (Move from Probably yes to Yes)

Votes	Yes	No	Number voting	Number abstains
1	15	0	15	1