Rehabilitation interventions for oculomotor deficits in adults with mild traumatic brain injury: a systematic review protocol

Melissa Biscardi 1,2, Zane Grossinger,1 Angela Colantonio,1,2 Mark Bayley,3,4 Tatyana Mollayeva1,2

ABSTRACT

Introduction  Mild traumatic brain injury (mTBI) is the most common form of TBI with many individuals suffering from symptoms suggestive of deficits in oculomotor function. Although the symptoms are often experienced transiently, almost 50% of individuals will experience persistent symptoms. Oculomotor deficits can last months after injury and decrease function and the ability to participate in work, school and sport. To date, rehabilitation interventions targeting oculomotor deficits in mTBI have been reported on in several studies with varying study designs; however, the effectiveness of these interventions on measures of oculomotor function has not been established. The purpose of this paper is to present a protocol for a systematic review that aims to examine the effectiveness of rehabilitation interventions for improving function in adults with oculomotor deficits after mTBI.

Methods and analysis  Systematic searches in Medline Ovid, EMBASE, PsycINFO, CINAHL and Scopus will be conducted to identify experimental studies published in English from each databases inception date to present, involving adult patients with mTBI and oculomotor deficits. Citations will be saved and managed in EndNote V.20. Two independent reviewers will identify eligible studies and perform data abstraction. Any discrepancies will be solved by discussion, and a third reviewer will be consulted if necessary. A meta-analysis will be conducted for outcomes reported in two or more studies. The Preferred Reporting Items for Systematic Review and Meta-Analysis Protocol guidelines will be followed for reporting.

Ethics and dissemination  This study does not involve primary data collection; therefore, formal ethical approval by an institutional review board is not required. Final results will be disseminated through open-access peer-reviewed publications. Abstracts will be presented at suitable national and international conferences or workshops. Furthermore, important information will be shared with clinical authorities, clinicians and at affiliated research institution-based websites and relevant servers.

PROSPERO registration number  CRD42022352276.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ A strength of this systematic review with meta-analysis is combining data from several studies, the sample size and statistical power is increased and allows for more reliable and precise estimates of the intervention’s effectiveness.

⇒ Bias of the review is reduced by following the rigorous and transparent methodology outlined in this protocol and by systematically searching, selecting and evaluating studies, which will allow us to capture risk of selective reporting and methods-related biases if any.

⇒ Identifying sources of variability across studies, such as differences in study design, patient characteristics and intervention protocols, will help to identify potential factors that may influence differences in intervention’s outcomes.

⇒ By including studies from several countries and different mechanisms of injury, the review will provide a broader perspective on the restorative intervention effectiveness and increase the generalisability of the findings to a wider population with mild traumatic brain injury.

⇒ Limitations of the review include excluding non-English studies and publication bias.

INTRODUCTION

Rationale  Mild traumatic brain injury (mTBI) is a major public health concern, with an estimated annual incidence of over four million cases across Canada and the USA combined.1,2 These mTBI cases confer significant costs and burden to the individual in the form of disability, disruption in social roles and quality of life. Furthermore, excess costs from healthcare utilisation in Ontario alone are estimated to be up to US$110 million per year as individuals wait for appropriate diagnosis and referral to tertiary care for management and treatment of persistent symptoms.3

According to the 1993 diagnostic criteria set by the mTBI Committee of the American Congress of Rehabilitation Medicine (ACRM), an mTBI is a type of brain injury induced by biomechanical forces and that results in a physiological disruption of brain
function as manifested by a Glasgow Coma Scale score between 13 and 15 at 30 min postinjury, and one or more of the following symptoms:

- Less than 30 min loss of consciousness.
- <24 hours post-traumatic amnesia.
- Impaired mental state at time of accident (confusion, disorientation, loss of memory, etc.).
- Transient neurological deficit.

These diagnostic criteria of mTBI were updated in May 2023 by the ACRM. However, the 1993 criteria are used for this review given the review will be of studies published before the updated definition of mTBI was published. Many individuals have transient symptoms and recover without complications. Recent research has shown that between 21% and 46% of individuals do not recover within 6 months of their initial injury. These individuals experience a variety of persistent symptoms, with some of the most troubling being symptoms related to oculomotor deficits. These symptoms can manifest as blurred vision, trouble reading, difficulty in busy environments, visual motion sensitivity and abnormal adaptations to focusing the eyes. Therefore, it is not surprising that oculomotor deficits are reported in up to 85% of individuals who have sustained a mTBI.

The presence and persistence of oculomotor deficits following mTBI have been examined in previous systematic reviews. The results highlighted common concerns in multiple conjugate eye movements including pursuits, saccades, near point of convergence and near point of accommodation. Pursuits are smooth eye movements that involve following or tracking a moving target. Saccades are rapid movements of the eyes that abruptly change the point of fixation bringing a new target to the centre of the fovea. Vergence movements are disjunctive movements of the eyes (convergence or divergence) that align the fovea of each eye with visual targets. Accommodation refers to the ability of the eye to focus on images that are near or far by changing the shape of the lens. Deficits in these eye movements can contribute to the commonly observed symptoms in mTBI such as blurred vision, trouble reading, difficulty in busy environments and visual motion sensitivity.

Research suggests that targeted interventions for oculomotor deficits can be used to support recovery following mTBI. Interventions for oculomotor deficits are categorised as restitutive, compensatory, substitutive or pharmacological. Restitutive interventions, which are the focus of this protocol, are those that involve strategies that help restore the function of oculomotor tissue, for example, interventions that use specific eye exercises to train an eye movement that is deficient. Restitutive oculomotor interventions in mTBI are carried out by clinicians and include training of the impaired function and/or repetitive stimulation of a specific eye movement, such as pursuit or saccade training.

Previous attempts to consolidate research on oculomotor interventions overall have had a number of limitations: (1) combining studies involving patients with a variety of TBI severities (mild, moderate, severe) and type of brain injury (traumatic and non-traumatic origin) thereby limiting the analysis of a specific benefit of oculomotor rehabilitation for mTBI; (2) providing a narrative review of findings versus a meta-analysis and (3) including both pharmacological and rehabilitation approaches in the review thereby limiting the analysis of a specific benefit of oculomotor rehabilitation.

Therefore, a systematic review focusing on restitutive oculomotor rehabilitation interventions in adults with mTBI is needed to evaluate the effectiveness of these strategies and identify potential targets and avenues for future research for this population.

**Objectives**

The main objective of this systematic review is to summarise evidence and critically appraise the evidence on the timing and frequency of administration, and the efficacy of restitutive oculomotor intervention in adults with mTBI. Further to this, the secondary objective of the systematic review is to apply a sex and gender lens to both treatment and comparator arms when analysing and reporting results. The review will consider efficacy of restitutive interventions for reducing oculomotor deficits compared with placebo, alternative treatment (compensation, substitution, pharmacological) or no treatment.

**METHODS**

This protocol for this systematic review is reported in compliance with the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols 2015 (PRISMA) Checklist. The review conceptualisation began in October 2021 and was registered with the International Prospective Register of Systematic Reviews on 23 August 2022 (PROSPERO registry CRD42022352276). Any revision made to this protocol will be updated on the PROSPERO registration.

**Eligibility criteria**

**Types of studies**

Included articles will be experimental research published in English, in peer-reviewed journals from inception up to February 2023. Included studies will be randomised controlled trials, case series and pre–post interventions of restitutive oculomotor rehabilitation in adults with mTBI. Studies will be excluded if they are conference abstracts, theses, reviews, non-peer-reviewed articles, grey literature or editorials as these sources are unlikely to present the information in the level of detail and rigour for the purposes of this systematic review. In addition, articles that include moderate and severe TBI, or other categories of brain injury, such as stroke will also be excluded.

**Types of participants**

For study participants, the review will include studies involving adults and young adults (mean aged over 16) of both sexes, with the presence of oculomotor deficits
(determined by assessment by an optometrist, neurooptometrist or other regulated healthcare professional) with a diagnosis of mTBI by a physician. This age was selected as in many US jurisdictions, 16 is considered the age of consent to participate in research (adulthood) and when the transition to adult care begins. Authors of studies not reporting how oculomotor deficits were determined but meeting other criteria will be contacted to determine if the study meets the inclusion criteria.

Types of interventions
The review will include studies of any restorative based oculomotor intervention compared with usual care, other intervention (compensatory, substitutive, pharmacological), placebo or no comparator. Interventions will be considered restorative if they include strategies aimed at restoring oculomotor function through the use of eye movement exercises.

Types of outcomes
The review will include studies reporting on oculomotor metrics, specifically, on measures of saccades, smooth pursuit, near point of convergence and accommodation.

Information sources
The lead author, in collaboration with an Information Specialist at Toronto Rehabilitation Institute, developed a comprehensive search strategy (online supplemental appendix A). Search terms were identified by reviewing the literature and previous systematic reviews on similar topics. The search concepts, headings and keywords from the search strategy are reported in Table 1. The final literature review using the search strategy will be performed as indicated below.

Search strategy
The eligibility criteria and search strategy were initially pilot tested in Medline Ovid on 11 January 2022. The strategy (online supplemental appendix A) was determined to be satisfactory by the lead author and information specialist (ie, it captured all known relevant studies). The results of the initial search in Medline Ovid is available in online supplemental appendix B. Using the piloted search strategy, the following databases will be searched:

- Embase Ovid (1946 to February 2023).

The search strategy used both text and index terms to capture the concepts ‘oculomotor’, ‘rehabilitation’ and ‘mild traumatic brain injury.’ Searches include similar concepts such as ‘vision therapy.’ Boolean Operators AND and OR are used to combine search concepts and search terms within each concept, respectively. Specific search terms and methods of combining terms varied depending on the specific parameters of the database. For example, MeSH terms were used for Medline. Search terms included but were not limited to: mild traumatic brain injury, concussion, brain injury, head injury oculomotor, saccade, pursuit, vergence, convergence, eye, ocular, vision and vision therapy (table 1). The database inception to the date of the search was chosen as the date range to maximise the breadth of the search results. The reference lists of retrieved publications that pass the first screen (detailed below), and references of review articles on the topic of vision therapy and/or oculomotor interventions following mTBI will be hand searched for additional studies. Experts in the fields, including authors of included publications, will also be contacted to identify additional relevant works.

Searching other resources
The reference lists of all full-text articles included in the review, and existing related reviews, will be examined to identify additional studies. Google Scholar will also be searched using derivations of ‘oculomotor’ and ‘mild traumatic brain injury’ and ‘rehabilitation.’ The clinical trials registries of the WHO (who.int/ictrp/en), USA (ClinicalTrials.gov), UK (ukctg.nihr.ac.uk) and Australia/
New Zealand (anzctr.org.au) will also be searched for relevant studies.

### Study records

#### Data management

Citations will be extracted into and stored within EndNote V.20 software (endnote.com). All data from included studies will be recorded using an Excel data extraction table (table 2). Excluded studies and reason for exclusion will be recorded in a separate table (table 3).

#### Selection of studies

Duplicates will be removed from the EndNote software. The screening and selection will be completed in two stages. Two review authors (MBi and ZG) will independently screen the titles and abstracts to identify all potentially relevant studies. Citations potentially meeting the inclusion and exclusion criteria will be included for a second screen, which will be a full text screen. During the second stage, assessment of the full text by two independent reviewers (MBi and ZG) will determine if the studies will be included in the review. At both screening stages, the two independent reviewers will assess studies’ eligibility. The inter-rater reliability will be calculated from a pilot study before each screening stage if the high agreement (kappa ≥80%) between two authors is achieved. If discrepancies are found at any stage the two review authors will further discuss, and a senior review author (TM) will be consulted to reach consensus at each level. The study selection process along with reasons for exclusions at the full-text level will be presented using a PRISMA study flow diagram.20

### Data collection and items

The standardised data extraction table will include author, publication year, study purpose, geographical location of the study, study setting, study participants’ demographic characteristics (eg, age, sex, time since mTBI, mechanism of injury, number of participants in the study/arm); rehabilitation interventions (eg, specifics of interventions, comparison), outcome results (eg, changes in oculomotor function, adverse effects) and funding. Two review authors (MBi and ZG) will independently extract data from all included studies. Inter-rater reliability will be calculated for confirmation of agreement between data extractors for two studies prior to completing the rest of the data set. Any disagreements on data extraction will be resolved through discussion, or by reaching out to senior review author (TM).

#### Outcomes

##### Types of outcome measures

**Primary outcomes**

The primary focus of the systematic review is assessment of evidence on the effect of restitutive oculomotor intervention on functional outcome measures:

- Saccade accuracy, speed and latency.
- Smooth pursuit accuracy.
- Near point of convergence in centimetres.
- Near point of accommodation in centimetres.
- Functional ability such as reading as measured by reading rate in words per minute.

This systematic review will also review and report on the available evidence related to self-reported oculomotor symptoms and quality of life measures of persons with mTBI in response to intervention. These outcome measures have been used in clinics to gather clinician-reported and person-reported data to evaluate the effectiveness of rehabilitation interventions, track progress and inform treatment decisions in persons with mTBI. Examples may include:

- Convergence Insufficiency Symptoms Survey.
- Canadian Occupational Performance Measure.

##### Adverse events

All reported adverse effects from the included studies will be summarised and considered in the analysis.

### Sex-based and gender-based parameters

The importance of considering sex and gender in health research is now well established.21

The review will examine how sex and gender were considered in the design of included studies, if there was adequate representation of males and females, and/or if reasons for the exclusion of males or females was justified.21 In accordance with the Sex and Gender Equity in Research (SAGER) guidelines, reporting of data disaggregated by sex, and an analysis of sex and gender differences in recruitment numbers or

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<tr>
<th>Table 2</th>
<th>Data form for abstracted data</th>
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<td><strong>Abstracted data</strong></td>
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<td>First author, date, country, study setting</td>
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<td>Sample size (N), no of mTBI, time of assessment post mTBI in months, mean age (age±SD), sex (%M), attrition</td>
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<td>Study design, intervention, timing and length of intervention, comparator, follow-up time, health professional delivering intervention</td>
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<td>Main statistical method</td>
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<td>Measures of oculomotor function</td>
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<td>Other symptom measures</td>
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<td>Sex specific reporting and analysis</td>
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<td>Adverse events</td>
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<td>Results</td>
<td>Change in oculomotor function 95% CI</td>
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<td>Change in symptom burden 95% CI</td>
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<td>Funding sources</td>
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<td>mTBI, mild traumatic brain injury.</td>
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<th>Table 3</th>
<th>Characteristics of excluded studies</th>
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<td>Author, date, country</td>
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response to treatment, even if negative, should be reported.\textsuperscript{21} If no sex-based and gender-based analyses were performed, the review will consider if authors indicated the reasons for lack of such analyses when discussing the limitations of their study and if the authors discussed whether such analyses could have affected the results.

### Assessment of risk of bias in included studies

Two authors (MBi and ZG) will independently assess study quality in two steps. Studies will be assessed with respect to potential sources of bias according to the most critical criteria related to internal and external design of the study. The risk of bias will be used to inform the overall grading of the evidence and will be completed as follows: For randomised controlled trials the Cochrane Risk of Bias (RoB-2) tool will be used to assess bias at the outcome level\textsuperscript{22} (table 4). For non-randomised studies, the National Institute of Health Quality Assessment Tool for Before-After Studies with No Control Group will be used\textsuperscript{23} (table 5). The second step will judge the presence of potential biases as ‘yes,’ ‘no,’ ‘not reported’ and ‘cannot determine.’ To ensure inter-rater reliability, the two independent reviewers will review one study of each type and review each item on the risk of bias list to clarify meaning, interpretation and ensure consistency. Once the risk inter-rater reliability is established, the remaining studies will be reviewed independently and then risk of bias scores will be compared between reviewers. Disagreements between the review authors over the quality assessment of studies will be resolved by discussion, with the involvement of a senior review author where necessary.

### Data Synthesis

Data synthesis will involve bringing together data from included studies that address each of the review objectives with the aim of drawing conclusions about this body of evidence. This will include tabulation that organises elements of included studies including the details of

### Table 4  Quality of studies using Cochrane RoB-2 tool

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<th>Risk-of-bias judgement low/high/some concerns</th>
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<tr>
<td>Optional: What is the overall predicted direction of bias for this outcome?</td>
<td>Favours experimental/favours comparator/towards null/away from null/unpredictable/NA</td>
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<th>Overall risk-of-bias judgement</th>
<th>Criteria</th>
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<tr>
<td>Low risk of bias</td>
<td>The study is judged to be at low risk of bias for all domains for this result</td>
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<td>Some concerns</td>
<td>The study is judged to raise some concerns in at least one domain for this result, but not to be at high risk of bias for any domain.</td>
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<td>High risk of bias</td>
<td>The study is judged to be at high risk of bias in at least one domain for this result. Or The study is judged to have some concerns for multiple domains in a way that substantially lowers confidence in the result.</td>
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NA, not available; RoB, risk of bias.

### Table 5  Quality assessment for before-and-after studies with no control group

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<th>Study\Criteria</th>
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<td>1. Was the study question or objective clearly stated?</td>
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<td>2. Were eligibility/selection criteria for the study population prespecified and clearly described?</td>
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<td>3. Were the participants in the study representative of those who would be eligible for the test/service/intervention in the general or clinical population of interest?</td>
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<td>4. Were all eligible participants that met the prespecified entry criteria enrolled?</td>
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<td>5. Was the sample size sufficiently large to provide confidence in the findings?</td>
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<td>6. Was the test/service/intervention clearly described and delivered consistently across the study population?</td>
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<td>7. Were the outcome measures prespecified, clearly defined, valid, reliable and assessed consistently across all study participants?</td>
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<td>8. Were the people assessing the outcomes blinded to the participants’ exposures/interventions?</td>
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<td>9. Was the lost to follow-up after baseline 20% or less? Were those lost to follow-up accounted for in the analysis?</td>
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<td>10. Did the statistical methods examine changes in outcome measures from before to after the intervention? Were statistical tests done that provided p values for the prechanges to postchanges?</td>
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<td>11. Were outcome measures of interest taken multiple times before the intervention and multiple times after the intervention (ie, did they use an interrupted time-series design)?</td>
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<td>12. If the intervention was conducted at a group level (eg, a whole hospital, a community) did the statistical analysis take into account the use of individual-level data to determine effects at the group level?</td>
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interventions and comparators, the population, the setting in which the interventions were evaluated and the outcomes assessed. Studies will be tabulated by study, study setting, study participants’ demographic characteristics (ie, sex, age, time since injury), number of participants per study arm, specifics of the rehabilitation intervention, and outcome results such as changes in oculomotor parameters and adverse events.

Studies will be assessed for heterogeneity by examining the characteristics of the study and performing \( \chi^2 \) test for homogeneity if appropriate. If heterogeneity exists, we will consider a random effects model if it is clinically appropriate to combine the studies. Studies that address the review objectives will, when possible, be pooled in statistical meta-analysis. Specifically, quantitative data including ORs, relative risks and weighted mean difference with their 95% CIs will be extracted and analysed. In the event of high clinical heterogeneity (ie, different length of follow-up, varied interventions) combining results will not be appropriate and a narrative review will be conducted.

A summary of findings table will be provided and include date of publication, number of participants, dose (frequency, duration, timing) and content of the intervention, who delivered the intervention, sex and gender of participants, if multiple mTBIs were reported, mechanism of injury, geographical location and setting of the study and study findings. This will be based on the ‘characteristics of included studies table’ and will include an explicit reference to the table. Characteristics of excluded studies will also be reported with the reason for their exclusion. If possible, a visual display of results will be provided.

**Meta bias**
Authors of the original studies will be contacted to request access to missing study data to help assess for selective reporting bias. Selective reporting bias will also be assessed by comparing study participants and results across studies with the same author, to ensure the same study is not reported across multiple publications. In addition, the potential for publication bias will be examined by searching completed clinical trials in clinicaltrials.gov and contacting researchers if study results are not published.

**Confidence in cumulative evidence**
The strength of the body of evidence will be discussed using the strength of evidence grades and definitions described by the Agency for Healthcare Research and Reporting Quality. Specifically:

- **Insufficient:**
  - Evidence either is unavailable or does not permit a conclusion.
- **Low:**
  - Low confidence that the evidence reflects the true effect. Further research is likely to change the confidence in the estimate of effect and is likely to change the estimate.

**Medium:**
- Moderate confidence that the evidence reflects the true effect. Further research may change our confidence in the estimate of effect and may change the estimate.

**High:**
- High confidence that the evidence reflects the true effect. Further research is very unlikely to change our confidence in the estimate of effect.

**Patient and public involvement**
MBi is a health professional who had extensive clinical experience in the assessment and management of concussions. The initial concept of this review was inspired by observations in clinical practice and discussions with patients using variations of oculomotor rehabilitation with seemingly positive results. The need for concussion management strategies to be based on the highest level of evidence possible and consultation with TM led to the conceptualisation of the review. There has been no further patient or public involvement. Future dissemination of findings in a format suitable for public engagement via relevant community concussion groups is planned.

**DISCUSSION**
**Implications**
In rehabilitation, and mTBI in particular, most publications report small sample sizes that make it difficult to achieve adequate statistical power to infer clinical differences or to infer clinical significance between interventions, control or comparison groups. Combining the results in an evidence synthesis, allows us to make meaningful inferences regarding existing research. To this end, the objective of the proposed systematic review is to report on the content, timing and effectiveness of restitutive oculomotor rehabilitation for treatment of oculomotor deficits in individuals with mTBI while also considering sex and gender parameters.

The systematic review will contain a structured discussion, as described in the Cochrane Handbook. This will include a summary of the main findings, overall completeness of the findings and how well the evidence identified in the review addressed the review question, any outstanding uncertainties that were uncovered in assessing the quality of the evidence and a discussion on the completeness of the body of evidence for oculomotor rehabilitation in mTBI. Furthermore, implications for the generalisability of the findings to mTBI rehabilitation practice more broadly will be commented on. Implications for practice will be practical, specific and draw only on the evidence and data from studies that were reviewed and included in the review. The strength of the body of evidence will be discussed using the strength of evidence grades and definitions described by the Agency for Healthcare Research and Reporting Quality.
for Healthcare Research and Reporting Quality. Implications for future research will be made with particular attention to specific recommendations for the type of study, participant, intervention and outcome as a guide for recommendations. Finally, the extent to which the findings of the current review agree or disagree with those of other reviews will be discussed.

Strengths
A major strength of this study pertains to it being the first systematic review of its kind to focus specifically on oculomotor restitutive interventions in adults with mTBI, an objective to provide clinicians with an overview of all available evidence for informing treatment plans. By including a sex and gender-based analysis, this review will be relevant for healthcare practitioners who can better prescribe and adapt interventions to address oculomotor dysfunction in adults with mTBI based on these findings. The risk of bias assessment will facilitate detection of any flaws in each included study to enrich the data set and overall review and grading of the strength of the evidence. Transparent methods will be reported to allow clinicians and researchers the opportunity to assess the validity of the results.

Limitations
There are limitations of the study. This systematic review may exclude some studies that explored mTBI but also included other types of brain injury. Additionally, while maintaining quality of study data through the inclusion of only peer-reviewed materials, it increases the risk of missing current and relevant information that may progress knowledge in this area. Other limitations include limiting to English language. Despite these limitations, this protocol is for a review that comprehensively synthesizes evidence on oculomotor rehabilitation in adults with mTBI.

Ethics and dissemination
This study does not involve primary data collection; therefore, ethical approval is not required. Review results will be disseminated through peer-reviewed publications, scientific meetings, affiliated research institution-based website, clinician and patient focused mTBI community groups who may find the results of interest. Any important amendments to the protocol will be documented on the PROSPERO website and in the final publications.

Twitter Mark Bayley @DocMarkBayley
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Contributors MBi and TM conceived and designed the review. MBi and TM interpreted the data. MBi drafted the protocol. JA and MBa searched the databases. SB assisted with the search strategy. MBi developed the first draft of the protocol manuscript, then MBi, ZG, AC, MBa and TM edited the manuscript. All authors read and approved the final manuscript prior to submission for publication.
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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

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ORCID iD
Melissa Biscardi http://orcid.org/0000-0002-4745-5606

REFERENCES
Appendix A: Supplemental material: Search strategy

Medline Ovid

1. exp Brain Concussion/
2. Brain Injuries/ or Brain Injuries, Traumatic/ or Brain Injury, Chronic/ or Craniocerebral Trauma/ or Head Injuries, Closed/
3. (brain adj3 injur*).tw,kf.
4. concuss*.tw,kf.
5. post*concuss*.tw,kf.
6. (mild adj6 brain* injur*).tw,kf.
7. (mild adj6 head injur*).tw,kf.
8. mtbi.tw,kf.
9. Craniocerebral Trauma.tw,kf.
10. head injur*.tw,kf.
11. traumatic brain injur*.tw,kf.
12. 1or2or3or4or5or6or7or8or9or10or11
13. exp oculomotor muscles/
14. Eye Movements/ or Convergence, Ocular/ or Fixation, Ocular/ or Nystagmus, Physiologic/ or Pursuit, Smooth/ or Saccades/ or Vision, Ocular/
15. saccad*.tw,kf.
16. (smooth adj pursuit*).tw,kf.
17. converg*.tw,kf.
18. vergence.tw,kf.
19. divergence.tw,kf.
20. near point convergence.tw,kf.
22. (ocular adj fixation).tw,kf.
23. nystagmus.tw,kf.
24. ocular motility.tw,kf.
25. eye tracking.tw,kf.
26. (vis* adj2 therap*).tw,kf.
27. (vis* adj3 (train* or rehab*)).tw,kf.
28. visuomotor.tw,kf.
29. 13or14or15or16or17or18or19or20or21or22or23or24or25or26or27or28
30. 12 and 29
Appendix B: Search results Medline January 11, 2022

Database: Ovid MEDLINE: Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE® <1946-Present> (Searches completed on January 11, 2023)

Search Strategy:

--------------------------------------------------------------------------------
1 exp Brain Concussion/ (11885)
2 Brain Injuries/ or Brain Injuries, Traumatic/ or Brain Injury, Chronic/ or Craniocerebral Trauma/ or Head Injuries, Closed/ (90700)
3 (brain adj3 injur*).tw,kf. (91812)
4 concuss*.tw,kf. (12507)
5 post*concuss*.tw,kf. (1656)
6 (mild adj6 brain* injur*).tw,kf. (7313)
7 (mild adj6 head injur*).tw,kf. (1352)
8 mtbi.tw,kf. (3889)
9 Craniocerebral Trauma.tw,kf. (1598)
10 head injur*.tw,kf. (26928)
11 traumatic brain injur*.tw,kf. (47197)
12 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 (151139)
13 exp oculomotor muscles/ (16040)
14 Eye Movements/ or Convergence, Ocular/ or Fixation, Ocular/ or Nystagmus, Physiologic/ or Pursuit, Smooth/ or Saccades/ or Vision, Ocular/ (75029)
15 saccad*.tw,kf. (14529)
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<td>(2910)</td>
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<tr>
<td>17</td>
<td>converg*.tw,kf.</td>
<td>(112804)</td>
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<td>18</td>
<td>vergence.tw,kf.</td>
<td>(2358)</td>
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<td>19</td>
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<td>(gaze adj fixation).tw,kf.</td>
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<td>(ocular adj fixation).tw,kf.</td>
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<td>(vis* adj3 (train* or rehab*)).tw,kf.</td>
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<td>28</td>
<td>visuomotor.tw,kf.</td>
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<td>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 (287226)</td>
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