CLINICAL APPLICATION OF VIRTUAL REALITY IN EXAMINATION OF CONCUSSIONS IN ADULTS: A SYSTEMATIC REVIEW

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OBJECTIVES

At the end of this presentation, attendees will understand the...

- necessity for the use of virtual reality in the assessment of concussion in adults
- clinical utility of virtual reality compared to current gold standard concussion assessment tools

INTRODUCTION

- Concussion, or mild traumatic brain injury (mTBI), is the most common form of TBI.[1]
- Effects can include headaches, problems with concentration, memory, balance, and coordination.[1]
- In a survey of 6,427 American adults, 29.8% reported experiencing at least one concussion in their life.[2]
- Current concussion examination relies heavily on subjective report of symptoms.[3]

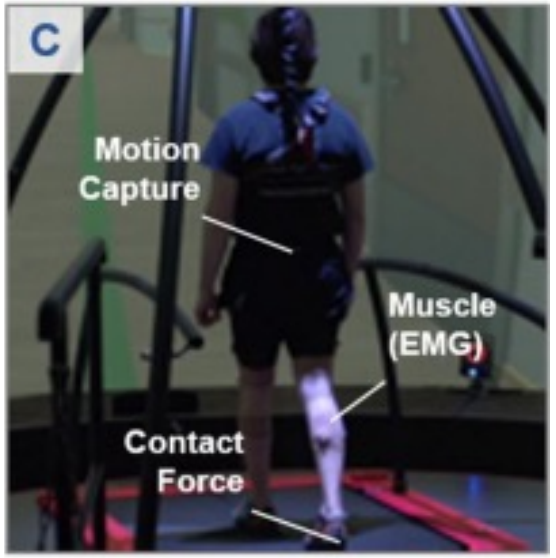
INTRODUCTION

- Previous systematic reviews exist exploring the application of VR as a means of assessment, screening, and rehabilitation in adolescents and adults with traumatic brain injuries (TBI) in various settings.[3]

- There is limited research focused on VR applications specifically for mild TBI (concussion) in the adult population.

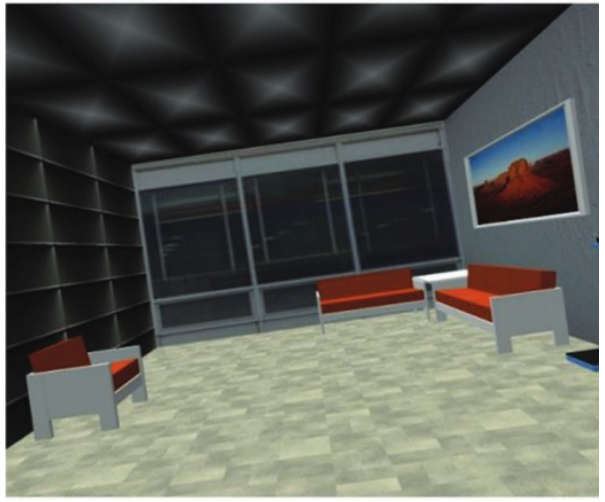
DEFINITIONS

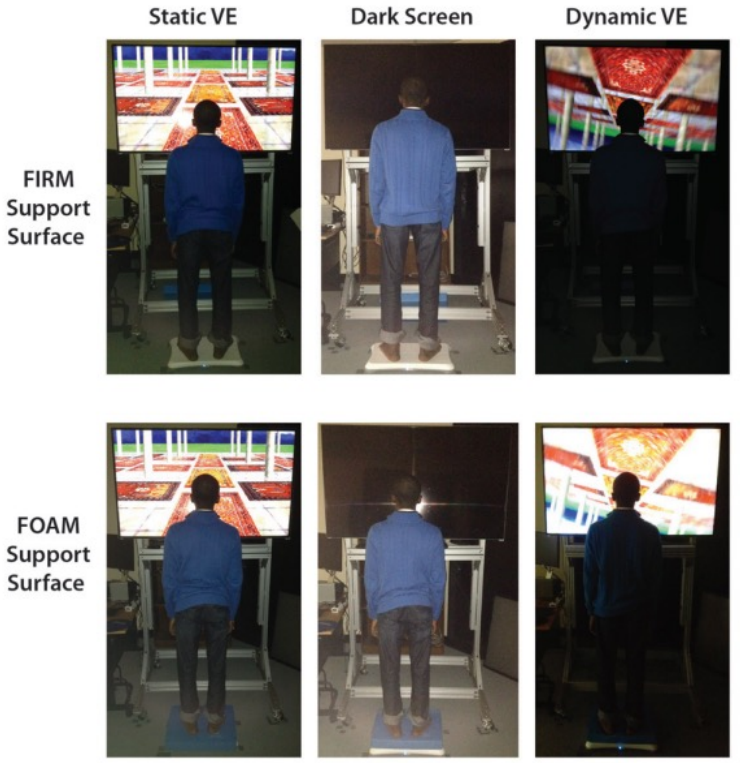
- Virtual Reality - A medium composed of interactive computer simulations that sense the participant's movements and replace or augment the feedback to one or more senses, giving the sensation of being mentally immersed in the simulation.[4]
- Immersive Virtual Reality - Participants are fully immersed and interact with the virtual environment (3D devices).[5]
- Non-Immersive Virtual Reality - Participants are not fully immersed within the virtual environment (2D devices such as keyboards).[5]



CAREN[6]

VisMini[7-9]





VETS[10]

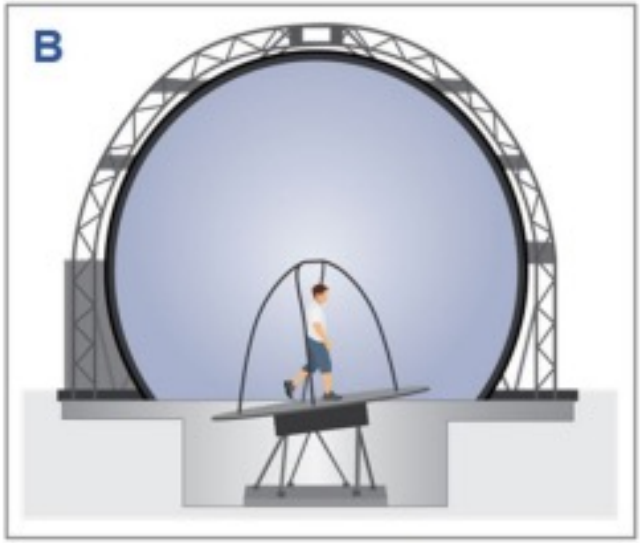
IMMERSIVE VIRTUAL REALITY

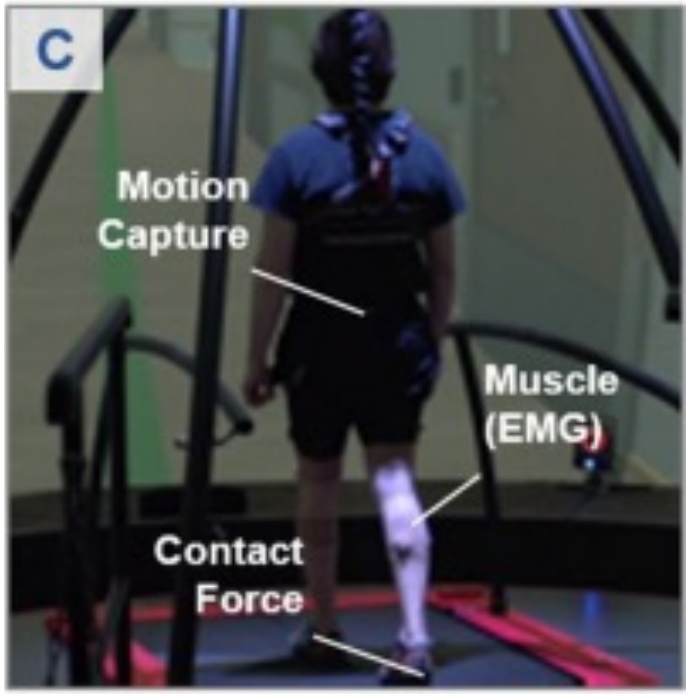
NON-IMMERSIVE VIRTUAL REALITY

VR PLATFORMS

Immersive Virtual Reality Systems

- CAREN[6]

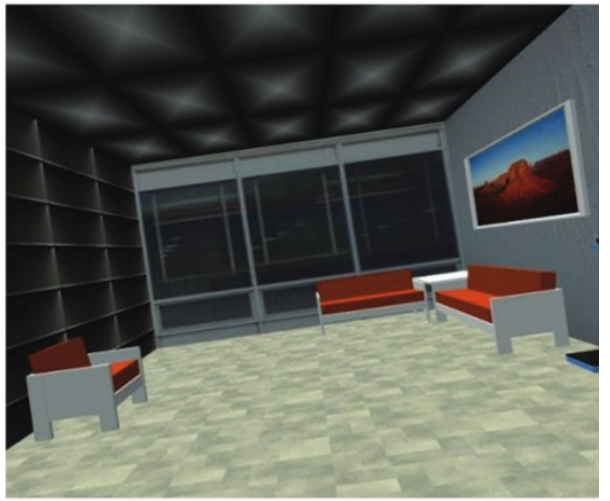


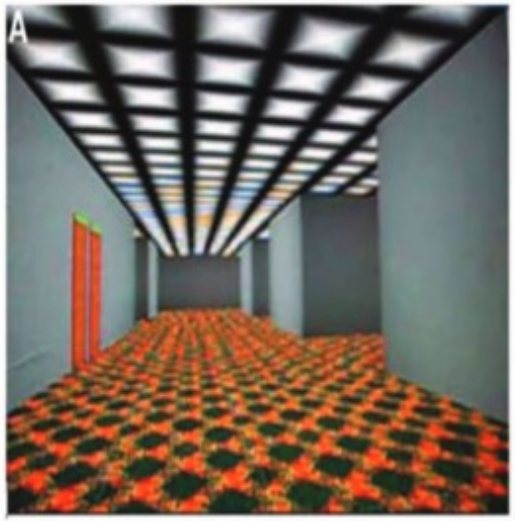


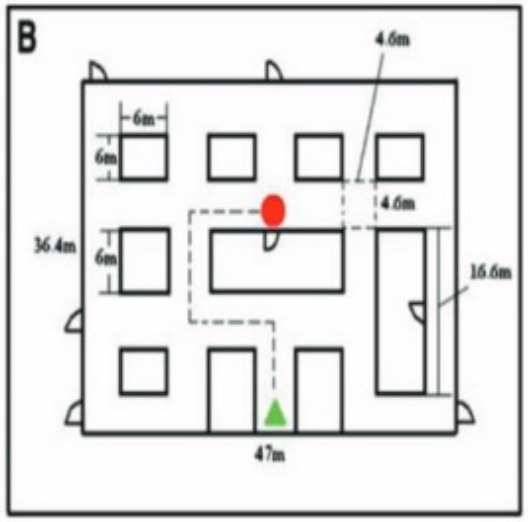
VR PLATFORMS

Immersive Virtual Reality Systems

- VisMini (3D Projection System)[7-9]



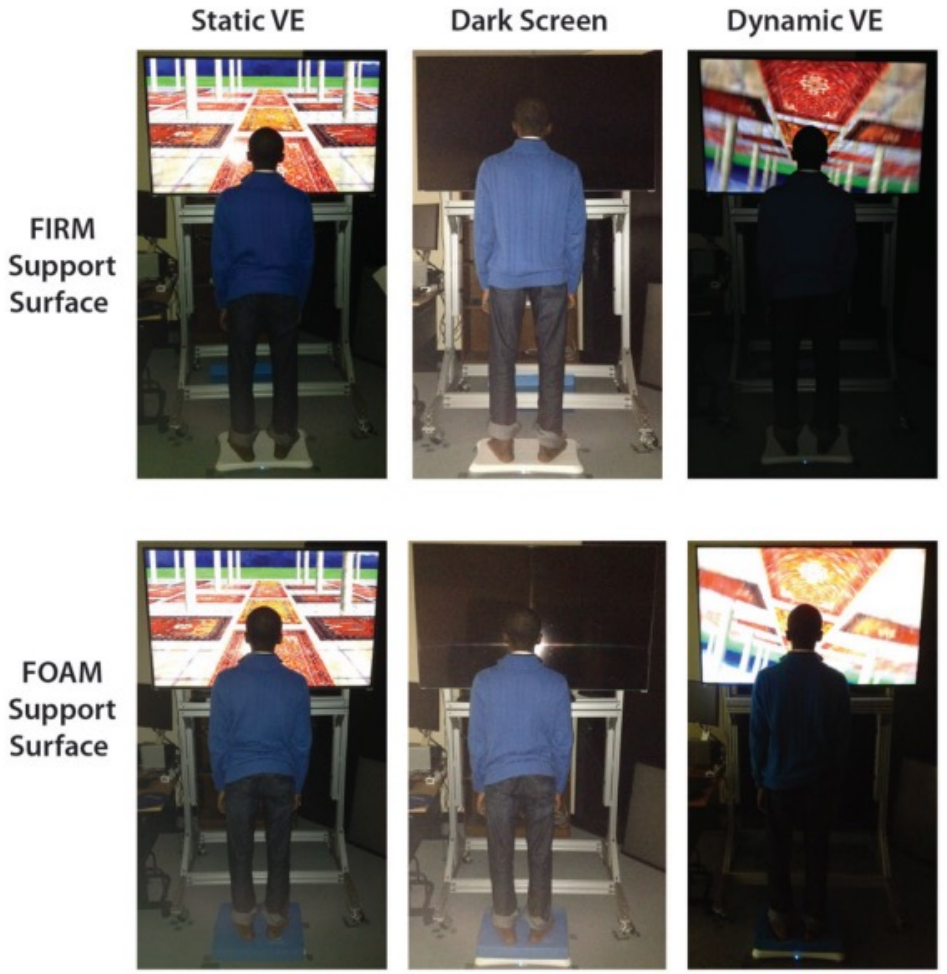




VR PLATFORMS

Non-Immersive Virtual Reality

- Virtual Environment TBI Screen (VETS)[10]



PURPOSE

The purpose of this systematic review was to examine the applications of virtual reality (VR) in the clinical management of adults with concussions.

METHODS

Search Engines:

- ProQuest, PubMed, ScienceDirect, and SpringerLink

Search Limits:

- English, peer-reviewed, human subjects, adults (18+) and 2012-2022

SEARCH TERMS

("Virtual Reality" **OR** VR)

AND

(Assessment **OR** Evaluation)

AND

Concussion

AND

Treatment

SELECTION CRITERIA

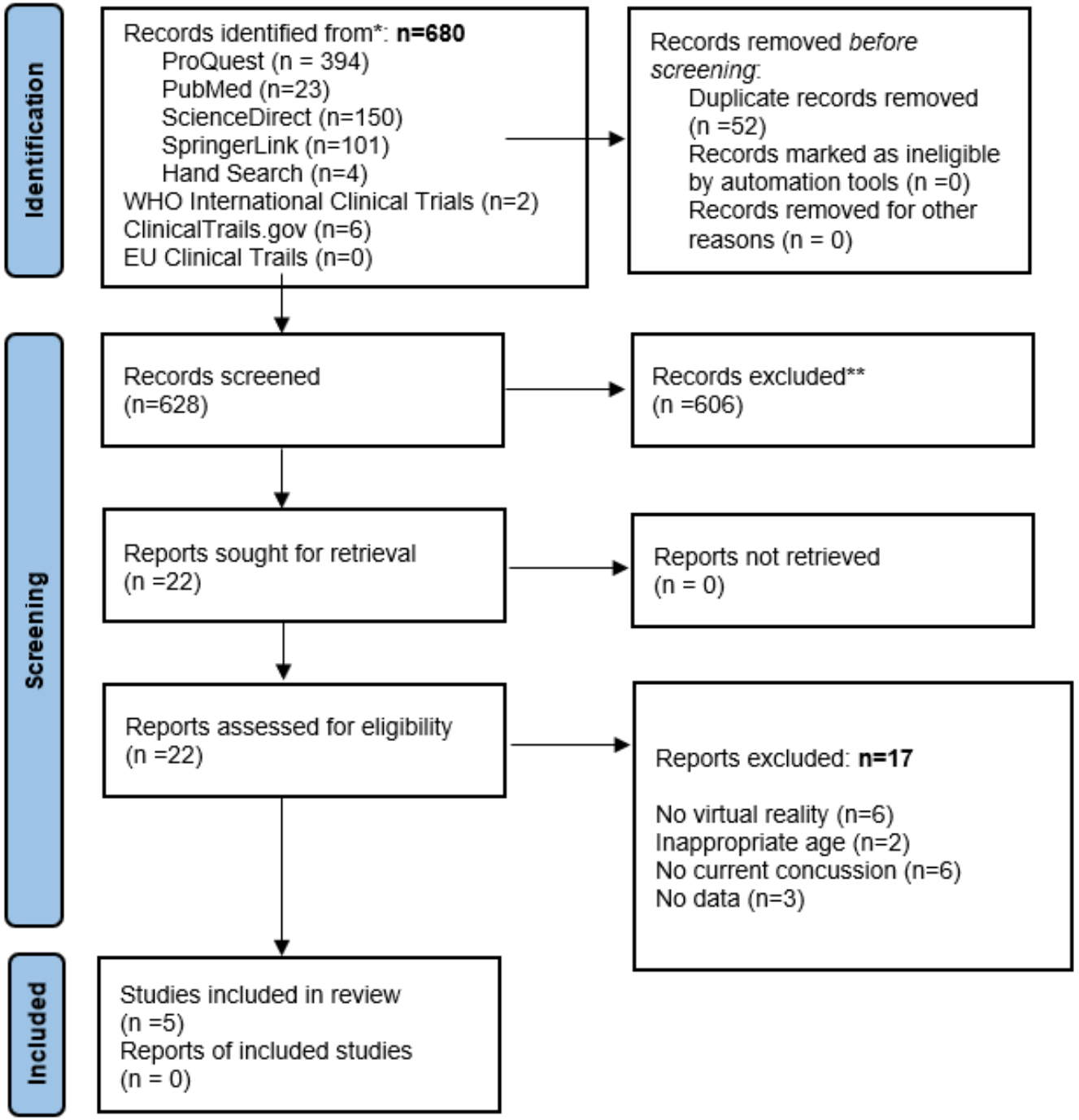
Selection criteria included:

- Adults with concussion
- Immersive and non-immersive virtual reality intervention
- Motor or cognitive outcome variables
- Quantitative study design

Methodological Assessment Tool:

- Oxford Center for Evidence Based Medicine (2011) (OCEBM)

RESULTS


Identification
Records identified from*: n=680
ProQuest (n = 394)
PubMed (n=23)
ScienceDirect (n=150)
SpringerLink (n=101)
Hand Search (n=4)
WHO International Clinical Trials (n=2)
ClinicalTrails.gov (n=6)
EU Clinical Trails (n=0)
Records removed before screening:
Duplicate records removed (n =52)
Records marked as ineligible by automation tools (n =0)
Records removed for other reasons (n = 0)
Screening
Records screened (n=628)
Records excluded** (n =606)
Reports sought for retrieval (n =22)
Reports not retrieved (n = 0)
Reports assessed for eligibility (n =22)
Reports excluded: n=17
No virtual reality (n=6)
Inappropriate age (n=2)
No current concussion (n=6)
No data (n=3)
Included
Studies included in review (n =5)
Reports of included studies (n = 0)

RESULTS

Non-Immersive VR Systems	Immersive VR Systems
VETS (1/5)[10]	VisMini (3/5)[7-9]
VTC Open GL Developing Kit (1/5)[9]	CAREN (1/5)[6]

RESULTS

Author, Year	OCEBM Level of Evidence And Design	Key Findings
Rao et al., 2020[6]	Level 3 Non-Randomized Controlled Cohort	Features from **sensorimotor perturbations are effective in detecting mTBI balance impairments** as compared to standard clinical tests.
Teel et al., 2016[7]	Level 3 Non-Randomized Controlled Cohort	Developed cutoff scores, specificity, and sensitivity for determining lingering balance deficits using VisMini.

RESULTS

Author, Year	OCEBM Level of Evidence And Design	Key Findings
Teel et al., 2016[8]	Level 3 Non-Randomized Controlled Cohort	Determined cutoff scores, sensitivity, and specificity for determining spatial **navigation/memory**, attention, **whole body reaction time**, and **VR neuropsychosocial battery** deficits using VizMini and VTC Open GL Developing Kit
Teel et al., 2015 [9]	Level 3 Non-Randomized Controlled Cohort	VR balance balance model using VizMini **validly measures postural stability** and is capable of determining balance deficits post-concussive injury

RESULTS

Author, Year	OCEBM Level of Evidence And Design	Key Findings
Wright et al., 2017[10]	Level 3 Non-Randomized Controlled Cohort	**Determined that VETs is an accurate and valid measure for determining balance impairments following mTBI.**

RESULTS

- A total of 680 studies were screened for eligibility. After detailed appraisal, 5 met selection criteria.
- Sample sizes ranged from 21 to 152 participants:
  - Concussed participants (n=101)
  - Healthy participants (n=382)
- All studies conducted single-day testing with no follow-up.

RESULTS

- 2 of 5 studies using VisMini established Sensitivity (Sen) and Specificity (Spe) with cut-off scores (0-10 pts) to indicate:[7-8]

	Sensitivity	Specificity	Cut-Off Scores
Impaired Reaction Time	95.2%	89.1%	6.75 points
Memory	95.8%	91.4%	7.50 points
Balance	85.7%	87.8%	8.25 points
Attention	54.2%	30.5%	9.50 points

- 1 of 5 studies using VETs determined 81.8% Sen and 85.7% Spe when examining sensory organization conditions to identify concussion deficits.[10]

RESULTS

- Statistically significant between-group differences:
  - Concussed groups performed lower in:
    - Visuospatial navigation[8]
    - Detection of sway/reaction time[8]
    - Steady state balance[8]
- One study using CAREN found greater discrimination of those with concussion using perturbations during walking.[6]

CONCLUSION

- Moderate evidence suggested effective use of VR to identify motor and cognitive impairments related to concussions in adults, particularly for postural control.

CLINICAL RELEVANCE

- Physical therapists should consider using VR for examination of patients with concussions to obtain objective, predictive data on residual impairments.

- VisMini and VETs assessments yielded higher sensitivity and specificity than current gold standard assessments such as BESS and SOT.

CLINICAL RELEVANCE

- If a VR system is not available, diagnostic findings may be useful for clinical applications to target areas:
  - Postural control
  - Reaction time
  - Motor strategy
  - Perturbations during gait
- VR may be used in return to sport protocols with better sensitivity to detect residual deficits than current clinical assessments.

LIMITATIONS

Limitations include:

- Small sample sizes
- High cost of some VR systems
- Same lead author for 3 of 5 studies
- Short-term outcomes for all studies

FUTURE RESEARCH

- Explore the use of virtual reality for long-term outcomes as well as with treatment for concussed participants.

- Evaluate the cost vs effectiveness trade-off of more easily accessible virtual reality programs.

THANK YOU

- DPT Faculty and Staff
- Fellow DPT Peers
- Ian O'Hara
- Attending Clinicians

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QUESTIONS?