

The use of a visual motor test to identify lingering deficits in concussed collegiate athletes

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The Use of a Visual Motor Test to Identify Lingering Deficits in Concussed Collegiate Athletes

Journal of Clinical and Translational Research

Dear author(s),

Reviewers have submitted their critical appraisal of your paper. The reviewers' comments are appended below. Based on their comments and evaluation by the editorial board, your work was FOUND SUITABLE FOR PUBLICATION AFTER MINOR REVISION.

If you decide to revise the work, please itemize the reviewers' comments and provide a point-by-point response to every comment. An exemplary rebuttal letter can be found on at <http://www.jctres.com/en/author-guidelines/> under "Manuscript preparation." Also, please use the track changes function in the original document so that the reviewers can easily verify your responses.

Your revision is due by Feb 14, 2020.

To submit a revision, go to <https://www.editorialmanager.com/jctres/> and log in as an Author. You will see a menu item call Submission Needing Revision. You will find your submission record there.

Yours sincerely,

Nicholas G Murray, Ph.D.
Editorial Board Member
Journal of Clinical and Translational Research

Reviewers' comments:

Reviewer #1: Manuscript Title: The Use of a Visual Motor Test to Identify Lingering Deficits in Concussed Collegiate Athletes

This study investigated how a visual motor coordination test could identify impairments among collegiate student athletes who have demonstrated clinical recovery from concussion relative to controls. Overall, the manuscript is well written and conveys some interesting points, albeit with a small sample. The authors should be sure to not overstate their findings, given the small sample size and limitations of the test battery.

Specific comments:

Note, line numbers refer to those that the authors inserted (continuous throughout the manuscript, not based on the specific page)

Abstract, lines 18-19: A*Average score is not defined, and should be somewhere in the abstract (generally, what are we talking about here?)

Line 27- be more specific to the actual paradigm used here. The statement that there are no visual motor coordination deficits after concussion recovery is a bit misleading, because only three outcomes were assessed, and there are many other ways that one could assess visual-motor coordination.

Line 30- persistent neurological impairments are commonplace? Is this truly the case? It is commonly accepted that symptom recovery occurs within 2-4 weeks of injury on average, but the timing of recovery of different neurological functions are not as clear in the literature.

Line 56- the two references provided are from mild head injury, and both >10 years old. Is this the same expected timeline as the concussion literature specified in the prior paragraph? Are there more recent studies on this topic?

The introduction lacks any information about published literature on visual deficits in general, but instead focuses on cognitive deficits. There are many different paradigms that exist to assess vision (convergence, tracking, saccadic movement, for example). Some mention of these will help to make the rationale for this study more complete.

Lines 110-115: for the two exams: some description of how outcomes are obtained and what the specific outcomes are that will then be used for hypothesis testing should be mentioned here.

Line 122 & 136: If all participants had a baseline test and two post-concussion tests, why isn't the baseline data presented. This would make the study stronger by being able to compare both groups before/after injury.

Line 132: Were all RTP progressions 6 days? There is likely variable from patient to patient.

Line 137: What were the matching criteria for control subjects?

Line 176 is in opposition to Line 122: were participants tested before the injury or not?

Were any power analyses conducted a-priori? How are the authors sure that the sample isn't simply sufficiently powered to detect between group differences? The authors rely on the use of post-hoc power analyses. They should provide more information to the reader about why these contain any useful information about interpretation of the results. As written, this is not clear.

Line 226: How is this paradigm translational? Is it truly uncovering something mechanistic? Or, is it feasible to assess in most clinical settings, given its size and cost?

Line 231: As with the abstract, be more specific to the actual paradigm used here. Only one method to assess visual motor coordination deficits is being used here.

Line 234: Could different injuries (closed head injury vs. concussion) help explain the differences in results between the Heitger study and this one?

Line 247: what is "documented visual dysfunction"? Something other than the paradigm used here?

Line 258: Could it also be that it is a difficult task for uninjured (control) patients to complete, thus making the difference between concussed and control groups minimal? Is there a way to potentially reduce or increase complexity to increase sensitivity?

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Reviewer #2: Overall well written paper, with no concern over any methods or interpretations. Please find line by line comments below.

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321-322: To what power?

324: if expanding on ImPACT, SAC, BESS within, make sure to state that using their pre-college career baselines may be a limitation.

391: correct double title in citation

Author's rebuttal

Reviewers' comments:

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- We thank the reviewer for their time and efforts on this review and we appreciate the work to improve the manuscript. Additionally, we would like to thank the reviewer for the kind comments within and we have provided a point by point response to each comment and concern below.

Specific comments:

Note, line numbers refer to those that the authors inserted (continuous throughout the manuscript, not based on the specific page)

Abstract, lines 18-19: A* Average score is not defined, and should be somewhere in the abstract (generally, what are we talking about here?)

- Expanded on line 19 as this being the average number of lights hits on A* exam and the section now reads, "A* Average score (average number of lights hit on A* exam)." The manuscript has been updated throughout to clarify that A* score is the A* average score.

Line 27- be more specific to the actual paradigm used here. The statement that there are no visual motor coordination deficits after concussion recovery is a bit misleading, because only three outcomes were assessed, and there are many other ways that one could assess visual-motor coordination.

-Expanded on lines 27-28 to be specific to the Dynavision D2 paradigm and now reads, "no persistent deficits were identified in visual motor coordination beyond clinical recovery when assessed by Dynavision D2" This section is limited in its discussion given the word count limitation of the abstract.

Line 30- persistent neurological impairments are commonplace? Is this truly the case? It is commonly accepted that symptom recovery occurs within 2-4 weeks of injury on average, but the timing of recovery of different neurological functions are not as clear in the literature.

- Edited lines 31-32 to read: "While post-concussion neurophysiological deficits persist beyond clinical recovery..." This is in reference to Kamins et al 2017 and Haider et al 2018, which reference multiple studies in which physiological dysfunction (e.g., dual-task gait,

neuroimaging, blood based biomarker, EEG, etc.) frequently outlast clinical measures of recovery (e.g., SAC, BESS, ImPACT).

Line 56- the two references provided are from mild head injury, and both >10 years old. Is this the same expected timeline as the concussion literature specified in the prior paragraph? Are there more recent studies on this topic?

- Lines 56-58 have been updated to read: “Visual and oculomotor deficits, assessed by tests like the King-Devick test or vestibular/oculomotor screening (VOMS), are becoming more commonplace post-concussion^{15,16}. Moreover, concussion adversely affects visual motor coordination (VMC) up to one year post-injury which is well beyond the typical two week clinical recovery.¹⁷⁻¹⁹” Updated references (15): Sussman et al (2016); (16) Kontos et al (2016); and (18) Locklin et al (2010).

The introduction lacks any information about published literature on visual deficits in general, but instead focuses on cognitive deficits. There are many different paradigms that exist to assess vision (convergence, tracking, saccadic movement, for example). Some mention of these will help to make the rationale for this study more complete.

- Information added to the introduction lines 56-58 regarding the prevalence of visual and oculomotor deficits post-concussion to read: “Visual and oculomotor deficits, evidenced by increases in King-Devick test completion time or a positive vestibular/oculomotor screening (VOMS), are commonplace post-concussion^{15,16}. Moreover, concussion adversely affects visual motor coordination (VMC) up to one year post-injury which is well beyond the typical two week clinical recovery” This builds on the previously provided brief neurophysiology of vision presented on lines #59-65

Lines 110-115: for the two exams: some description of how outcomes are obtained and what the specific outcomes are that will then be used for hypothesis testing should be mentioned here.

- The description of outcomes are presented in lines 157-166 under Procedures.

Line 122 & 136: If all participants had a baseline test and two post-concussion tests, why isn't the baseline data presented. This would make the study stronger by being able to compare both groups before/after injury.

- We apologize for the lack of clarity on the initial submission. The Dynavision task was not a part of baseline assessment, but rather part of this specific study which assessed concussion group participants and matched controls. The comment on Line #122-124 refers specifically to the clinical baseline which is the ImPACT, SAC, and BESS and we have revised this sentence to be clearer about this point. The sentence, on Line #128-129, now reads, “At the beginning of their collegiate athletic career, the student-athletes performed the clinical assessment battery (i.e., baseline test) consisting of ImPACT, SAC, BESS, and GSC.”

Line 132: Were all RTP progressions 6 days? There is likely variable from patient to patient.

- All participants completed 6 days RTP progressions; if the individual suffered a setback they were excluded and this was part of the challenge in participant recruitment. Unfortunately, this also lowers the observed power of the study. (See lines 102-104 in Methods).

Line 137: What were the matching criteria for control subjects?

- This information was presented in lines 98-99 and Table 1; participants were matched by sex, sport, position, and age (within 3 years). There were no significant differences for any of these demographics between groups. (Table 1)

Line 176 is in opposition to Line 122: were participants tested before the injury or not?

- Line 122 refers to the baseline assessment battery (ImPACT, BESS, SAC, GSC) that athletes completed prior to their season. Line 128-129 has been expanded upon to clarify this. Line 183 is in reference to the fact that baseline (i.e. preseason) Dynavision data are not available; lines 183-184 have been expanded upon to clarify that no preseason Dynavision data were available.

Were any power analyses conducted a-priori? How are the authors sure that the sample isn't simply sufficiently powered to detect between group differences? The authors rely on the use of post-hoc power analyses. They should provide more information to the reader about why these contain any useful information about interpretation of the results. As written, this is not clear.

- No, we attempted to recruit all student athletes who met the inclusion/exclusion criteria over the course of an academic year. This was part of a larger concussion research program. (line 324) We excluded participants for a variety of reasons (e.g. persistent concussion symptoms), regression in the step wise RTP protocol, participants were not willing to participate, etc. However, at the time we did not track reasons why, thus an exclusion flow chart is not available.

Line 226: How is this paradigm translational? Is it truly uncovering something mechanistic? Or, is it feasible to assess in most clinical settings, given its size and cost?

- This study was translational in the sense that it could be used as a laboratory test within the traditional clinical assessments of concussion. Most reaction time tests are computer based (mouse and click), whereas this is more of a translational to an athletic environment where participants have to respond with larger extremity movements according to various stimuli. This is broadly discussed on line numbers 309-317.

Line 231: As with the abstract, be more specific to the actual paradigm used here. Only one method to assess visual motor coordination deficits is being used here.

- Warm up trials description provided in line 161-164 for A* ("Participants were instructed to hit illuminated lights, deactivating them, using either hand as fast as possible for 60-s") and lines 165-169 for SVRT tests ("For the SVRT test, participants held down a button on the center of the board, during which a 2nd button 30 cm away would light up, they then released

the original button and reached to touch the 2nd button as quickly as possible with the same hand (Figure 1B).”)

Line 234: Could different injuries (closed head injury vs. concussion) help explain the differences in results between the Heitger study and this one?

- Yes, we have added this distinguisher to lines 248 that these were post-concussion patients vs. Heitger’s mild closed head injury patients with GCS scores 13-15 following a visit to the emergency department. (line 253).

Line 247: what is "documented visual dysfunction"? Something other than the paradigm used here?

- Line 248 expanded to describe “physician diagnosed post-concussion visual dysfunction based on visual symptom reporting”. This is per the Clark paper which methods describe “physician diagnosed visual dysfunction” which is from an inventory of patient reported symptoms.

Line 258: Could it also be that it is a difficult task for uninjured (control) patients to complete, thus making the difference between concussed and control groups minimal? Is there a way to potentially reduce or increase complexity to increase sensitivity?

-We respectfully disagree with the reviewer here as the more difficult the task the more likely it will discriminate groups. The research team matched control and concussion group participations closely, so there’s no reason to believe that the lack of difference between groups was due to task difficulty.

Line 291: the use of the term 'baseline' here is confusing. Is this pre-injury? If so, both groups are technically 'controls' since no concussion has happened. Or, is this the initial post-concussion and first control test? In either case, this terminology needs to be clarified throughout the manuscript.

- Line 299-301 clarified that Wilkerson’s data was collected at pre-season baseline, in contrast to our T1 scores. Now reads “Interestingly, they reported a pre-season baseline median score of 85 hits, greater than the median score (Concussion: 76.2 hits; Control: 77.7 hits) and mean scores (Concussion: 76.8 + 8.5 hits; Control: 75.8 + 12.4 hits) in both of our groups at baseline T1”

Reviewer #2: Overall well written paper, with no concern over any methods or interpretations. Please find line by line comments below.

We would like to extend our thanks and appreciation to the reviewer for their time and effort on this review as a means to approve the manuscript. Furthermore, we have provided a point by point response to each comment and concern below.

41: Provide a more recent citation as this is 13+ year old epi data.

- New source 1&2 added and updated introductory sentence with updated epi data. Lines 42-43 now reads: “Approximately 13-19% of all sports related injuries are concussions among American high school and collegiate athletes^{1,2}”. (#1: Marar et al (2012) *AJSM*; #2: Baugh et al (2018) *Sports Health*)

51: Correct wording to "These potentially" or "this potential"

- Correct as suggested to “This potential” on line 52.

63: Can you clarify how this is also different from visual motor processing speed, a composite score of ImPACT.

- Added how this the neurocognitive tests mainly measure visual reaction time from visual motor processing speed on lines 66-68 (“In concussion management, neurocognitive tests broadly measure simple visual reaction time, or visual motor processing speed, by assessing the speed one can press a key on a keyboard; a task that lacks ecological validity for athletes”). With ImPACT it is mainly assessing the ability of an individual to press a key on a keyboard, in terms of visual motor processing speed. Whereas activities like the Dynavision assess VMC through the use of processing visual information, planning, and control a multi-joint motor response.

72: Insert manufacturer/product information

- Added (D2 model, West Chester, OH) on line 76.

73: Student-athletes, but suggest leaving as just athletes

- We have retained the term "student-athlete" as the participant's institution was governed by the NCAA and this is the formal term they utilize.

79: What was the time point for this? Improvements were noted after a season? Year?

- Added timeline of before and during season on lines 82-83 to read “...form of visual motor skills training before and during the competitive season to improve performance, assess visuomotor reaction time, and reduce injury risk.”

84-85: Fragment sentence here. Please correct

- Corrected as suggested on line 83-84. Sentence now reads: “These players improved peripheral vision reaction time²⁹; interestingly, individuals with slower visuomotor reaction time at baseline had higher rates of musculoskeletal injury.²⁸”

90: Please state these 3 tasks, so they are similar to the abstract (average, simple visual reaction time, and movement time.

- Corrected as suggested in lines 92-93 to include average A*, SVRT-RT, and SVRT-MT.

95: Here you call the group "concussion" but in Table 1 they are called concussed. I would also suggest labeling control participants as "matched control" in Line 96 similar to how you

identified concussion. "Concussion" group is used in results and figures, so just keep Table 1 consistent.

- Added "control" to line 99 to clarify group names. Table 1 has been edited to be consistent as suggested with the label of "concussion" (line 150). Additionally, the manuscript has been edited throughout for consistency on "concussion" and "control" groups.

98: Excellent job stating why 4th consensus, despite not much difference in diagnosis criteria
- We thank the reviewer for the kind comment.

110: merge with paragraph above

- Merged as suggested (Line 114-115 now reads "...rings. Two exams were used...")

110-111: Is movement speed from A* exam? Please clearly state dependent variables here.

- Clarified in line 115 that movement speed is from SVRT to read "Two exams were used: 1) A* exam and the 2) SVRT test which assesses SVRT-RT and SVRT-MT."

120: May even suggest that they are deemed best practice by the consensus statement. While ImPACT is not part of the SCAT, 4th statement states that it may be of added benefit.

- We thank the reviewer for the insightful comment. Lines 125-126 added notion of best practice as suggested, to read "These assessments have been thoroughly described in the literature, and are frequently utilized by clinicians, and deemed best practice by the 4th CIS."

127: Don't recall CIS abbreviation above.

- Added abbreviation to line 102 to read "(4th CIS)".

Table 1: match "concussion" group term instead of "concussed"

- Fixed as suggested in line 150 and throughout the manuscript. Excellent point.

156-157: Is this the A* average score described in abstract?

- Yes, clarified in line 163 as "A* average score", as well as throughout the manuscript.

164-165: I would move the 2 measures up the merge with Line 160.

- Change made as suggested on lines 167-168.

234: Did you run analyses to see how the recovery of the Dynavision compared with ImPACT, symptoms, etc. This could very valuable information either for this paper or as a part 2/separate paper.

- This is a good idea that we had also considered when performing the analysis and writing this paper. However, under the medically managed protocol in place, there was no ImPACT test on T2. Secondly, there may or may not have been an ImPACT test at T1 as some participants "passed" ImPACT early on and T1 would be closer to when symptoms subsided

and there could be 48 – 72 hours (or more) since the last ImPACT test.

303: Write out and possibly expand on CARE Consortium.

- Expanded on lines 312-314 as suggested by describing the purpose of CARE and defining the abbreviation to read “Concussion Assessment, Research, and Education (CARE) Consortium protocol which studies the natural history of neurobiological and clinical recovery in student-athletes and military cadets.”

305: Lower case M.

-Corrected as suggested on line 316

321-322: To what power?

- Added power to line 332 to read “observed power was low (0.258).”

324: if expanding on ImPACT, SAC, BESS within, make sure to state that using their pre-college career baselines may be a limitation.

- Expanded on lines 335-336 to limitation of pre-college career baselines

391: correct double title in citation

- Corrected citation on line 425 for source 25 Covassin et al 2010.

2nd Editorial decision

05-Feb-2020

ef.: Ms. No. JCTRes-D-19-00039R1

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Journal of Clinical and Translational Research

Dear authors,

I am pleased to inform you that your manuscript has been accepted for publication in the Journal of Clinical and Translational Research.

You will receive the proofs of your article shortly, which we kindly ask you to thoroughly review for any errors.

Thank you for submitting your work to JCTR.

Kindest regards,

Nicholas G Murray, Ph.D.

Editorial Board Member
Journal of Clinical and Translational Research

Comments from the editors and reviewers: