

**Relationship between the Romberg test and the Wii Fit basic balance test  
and cognition in athletes with concussion**

Nicholas G. Murray, Anthony P. Salvatore, Joe Tomaka, Rebecca J. Reed-Jones

*Corresponding author:*

*Nicholas G. Murray, School of Health and Kinesiology, Georgia Southern University,  
Statesboro, Georgia, United States*

---

Handling editor:

Rowan van Golen

*Department of Experimental Surgery, Academic Medical Center, University of Amsterdam,  
Amsterdam, The Netherlands*

Review timeline:

Received: 25 January, 2016

Editorial decision: 3 March, 2016

Revision received: 1 April, 2016

Editorial decision: 3 April, 2016

Published online ahead of print: 15 April, 2016

---

1<sup>st</sup> editorial decision:

Date: 3-Mar-2016

Ref.: Ms. No. JCTRes-D-16-00002

Relationship between Static and Dynamic Postural Assessments and Cognition in Athletes with  
Concussion

Journal of Clinical and Translational Research

Dear Dr Murray,

Reviewers have now commented on your paper. You will see that major revisions are required before your manuscript can be considered for publication in JCTR. If you decide to revise the work, please submit a list of changes or a rebuttal against each point which is being raised when you resubmit your work. For your guidance, reviewers' comments are appended below.

Your revision is due by Apr 02, 2016.

To submit a revision, go to <http://jctres.edmgr.com/> 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

Rowan van Golen  
Associate Editor  
Journal of Clinical and Translational Research

\*\*\*\*\*Reviewer comments\*\*\*\*\*

Reviewer #1: Overall this paper is severely limited, particularly in the interpretation of the results. The question of whether the RT or WBBT are correlated with the IMPACT is of interest, as well as whether they are correlated with each other. However, the findings for the WBBT was not only negative for a positive correlation with the IMPACT, but it showed a negative correlation for the visual memory subset which is very difficult to explain, doesn't make much sense. The authors nonetheless conclude that the WBBT is a "superior test" to the RT because it requires higher cognitive functioning, but this is not at all supported by the data. The study likely needs more data on the WBBT/IMPACT, possibly more subjects; or maybe the data is misleading because elementary school students as well as adults are lumped together and one wonders whether the relationships may be different for the different ages.

#### Specific Comments:

- 1) Baseline Impact scores would be helpful, particularly for elementary/middle students. If not available, this should be addressed.
- 2) There is no data on number of prior concussions for the subjects, but this is important as those with multiple concussions may fare differently than those with a first concussion. This data if available should be included.
- 3) Page 11 line 11: "Overall the results only partially support this hypothesis" doesn't seem true - the results seem quite different from the hypothesis. I would rephrase to say something more to the effect of "In actuality the RT overall correlated better with the IMPACT than the WBBT."
- 4) Page 11 line 13: I would omit the word "conventional" - simply, statistical significance was not reached.
- 5) Page 14 Wii Fit Basic Balance test first paragraph: If the WBBT is negatively correlated with the IMPACT and in particular visual memory scores, than the entire explanation in this paragraph does not make sense; it seems that far from being correlated with higher cognitive functions as assessed by the IMPACT, these higher cognitive functions are not required or, worse, inhibit performance on the WBBT. The explanation that "Yet it could be that as the participants increase the level of difficulty on the WBBT they will not require a significant use of as many visual memory pathways to complete the task because of the low visual stimuli of the game" is flawed because those participants who did well on advanced levels of the WBBT also had to do well on the basic levels. Perhaps the IMPACT is not ideal in assessing higher cognitive functions required to perform the WBBT.
- 6) Page 14 Wii Fit Basic Balance test second paragraph: the conclusion that the WBBT is a better test for assessing higher cognitive functions is not at all supported by the data presented in this paper and thus should not be listed as a conclusion.
- 7) Page 15 line 12: "The WBBT involves the total body to achieve the desired game goals and maintain upright bipedal stance, while the ImpACT test is a seated computer based neurological assessment." It is unclear how the fact that one test requires seated posture and one an upright posture would have any bearing on whether they are correlated. One could say the same for the RT and the IMPACT.

8) The fact that the RT and WBBT are not significantly correlated is odd given that they both assess balance and should be addressed. In addition, it is odd that the WBBT did not correlate with the more basic brain functions including reaction time and processing speed, given that it too requires simple reflexes (as well as more advanced functioning, presumably). This should be addressed.

9) Page 17 line 5: it is misleading to say "Whereas, the WBBT was significantly related to visual memory" because it actually was negatively related."

---

Authors' rebuttal:

Overall this paper is severely limited, particularly in the interpretation of the results. The question of whether the RT or WBBT are correlated with the IMPACT is of interest, as well as whether they are correlated with each other. However, the findings for the WBBT was not only negative for a positive correlation with the IMPACT, but it showed a negative correlation for the visual memory subset which is very difficult to explain, doesn't make much sense. The authors nonetheless conclude that the WBBT is a "superior test" to the RT because it requires higher cognitive functioning, but this is not at all supported by the data. The study likely needs more data on the WBBT/IMPACT, possibly more subjects; or maybe the data is misleading because elementary school students as well as adults are lumped together and one wonders whether the relationships may be different for the different ages.

*Thank for the excellent comments. To address each particular concern mentioned above please see the below responses;*

- (1) Negative correlation for visual memory: Due to the coding of the data within SPSS where 0 = No impairment and 1 = impairment, this negative correlation can be explained. As the number of WBBT trials completed is for levels 1-5 and the impairment on the ImPACT test Visual Memory is coded (0 = No impairment, 1 = Impairment), a negative correlation would indicate that as the classification of impairment increased the number of WBBT trials completed would decrease. This has been added to the text (Page 10, Lines 1-8) with a figure to aid in demonstrating the results.*
- (2) Conclusion for WBBT as a superior test: The authors agree with the reviewer that these statements, although speculative, were incorrect and not supported by the data. This has since been removed and altered significantly.*
- (3) Need for additional subjects: The power analysis conducted for this dataset revealed that 49 subjects was needed to reach significance. As such, if the data was split to not include the different age groups (<15 under the age of 17 included in the study) significance level of the data will not be attained. Upon further review of the data (splitting by 17 and under and 18 and over) the data suggests a similar trend to the current study results. As this study was exploratory in nature, and the authors acknowledge the weakness of including a broad range of concussed individuals, it is important to point to potential*

*relationships or lack of relationships in the current dataset and attempt to address these moving forward with further research into each age range.*

Baseline Impact scores would be helpful, particularly for elementary/middle students. If not available, this should be addressed.

*Thank you for the comment. No baseline ImPACT scores were available for comparisons in this study, and this has been denoted in the limitations section (Page 16, Line 21 – Page 17, Line 1). The ImPACT data that was considered impaired or not impaired was based off a valid and reliable set of normative values provided by the creators of ImPACT for each age range in the study. As such, it ideal to have baseline measures to compare to, yet was extremely challenge to properly acquire these at the time of the study.*

There is no data on number of prior concussions for the subjects, but this is important as those with multiple concussions may fare differently than those with a first concussion. This data if available should be included.

*The authors agree with the comment by the reviewer and thank the reviewer for this important point. Unfortunately, no data was available regarding prior history of concussion beyond six months. As such, this is a limitation of the study and is denoted in the limitation section. Please see Page 16, Lines 19-20.*

Page 11 line 11: “Overall the results only partially support this hypothesis” doesn’t seem true – the results seem quite different from the hypothesis. I would rephrase to say something more to the effect of “In actuality the RT overall correlated better with the IMPACT than the WBBT.”

*The authors agree with the comment by the reviewer and thank the reviewer for this important point. The document has been adjusted to reflect a more toned down hypothesis. Please see Page 11, Lines 9-11.*

Page 11 line 13: I would omit the word “conventional” – simply, statistical significance was not reached.

*Thank you for this comment. The word “conventional” has been removed and altered.*

Page 14 Wii Fit Basic Balance test first paragraph: If the WBBT is negatively correlated with the IMPACT and in particular visual memory scores, than the entire explanation in this paragraph does not make sense; it seems that far from being correlated with higher cognitive functions as assessed by the IMPACT, these higher cognitive functions are not required or, worse, inhibit performance on the WBBT. The explanation that “Yet it could be that as the participants increase the level 8 of difficulty on the WBBT they will not require a significant use of as many visual memory 9 pathways to complete the task because of the low visual stimuli of the game” is flawed because those participants who did well on advanced levels of the WBBT also had to do well on the basic

levels. Perhaps the IMPACT is not ideal in assessing higher cognitive functions required to perform the WBBT.

*Thank you for this comment. The negative correlation is due to how the data was coded. Having an impairment on the ImPACT test or any subcomponents of the ImPACT test where coded as 0 = No, and 1 = Yes. As such, as the classification of impairment on Visual Memory increased (more towards 1) then the number of WBBT trials completed reduced. Therefore, the negative relationship between the WBBT and Visual Memory is correct and the following information is pertinent and aids in this understanding. The authors do apologize for not explaining this in adequate detail or sufficiently in the first review. This has been edited, clarified, and a new figure has been added to aid in this understanding. Please see Page 10 of the results, Figure 1, and the updated discussion starting on Page 14, Line 5.*

Page 14 Wii Fit Basic Balance test second paragraph: the conclusion that the WBBT is a better test for assessing higher cognitive functions is not at all supported by the data presented in this paper and thus should not be listed as a conclusion.

*Thank you for this comment. The reviewer is correct and this has been removed from the document.*

Page 15 line 12: “The WBBT involves the total body to achieve the desired game goals and maintain 13 upright bipedal stance, while the ImPACT test is a seated computer based neurological 14 assessment.” It is unclear how the fact that one test requires seated posture and one an upright posture would have any bearing on whether they are correlated. One could say the same for the RT and the IMPACT.

*Thank you for this comment. The original claim by the authors was unsubstantiated due to the lack of biomechanical center of pressure data to ascertain the underlying postural mechanisms behind the RT and the WBBT. As such, this section has been edited to reflect this view. Please see the edits and re-worked discussion starting on Page 14 Line 5 and continuing to Page 16 Line 13.*

The fact that the RT and WBBT are not significantly correlated is odd given that they both assess balance and should be addressed. In addition, it is odd that the WBBT did not correlate with the more basic brain functions including reaction time and processing speed, given that it too requires simple reflexes (as well as more advanced functioning, presumably). This should be addressed.

*Thank you for this comment. The authors agree that this was an odd finding of the study. However, it is possible that the RT and the WBBT are measuring two separate aspects of postural control. During motor movements, specifically postural stability, certain motor patterns or programs can be overwritten or repressed given the task (Winter 1995). This indicates the brains plastic ability to adapt to the novel task and find the best way of attaining the proper outcome. As such, the reflexive motor program the brain used for the RT could not have been an*

*important factor or program used to accomplish the WBBT. However, this is speculative given the lack of true biomechanical data such as center of pressure metrics or motion capture to answer this question. This has been addressed and added to the document. Please see Page 15, Lines 3-Page 16 Line 13.*

Page 17 line 5: it is misleading to say “Whereas, the WBBT was significantly related to visual memory” because it actually was negatively related.”

*Thank you for this comment. The word negatively has been added. Please see page 17, Line 5.*

---

2<sup>nd</sup> editorial decision:

Date: 3-Apr-2016

Ref.: Ms. No. JCTRes-D-16-00002R1

Relationship between Static and Dynamic Postural Assessments and Cognition in Athletes with Concussion

Journal of Clinical and Translational Research

Dear Dr Murray,

I am pleased to inform you that your manuscript has been accepted for publication in the Journal of Clinical and Translational Research. The proofs of your work will be prepared and send to you for review in due course.

Thank you for submitting your work to JCTR.

Kindest regards,

Rowan van Golen

Associate Editor

Journal of Clinical and Translational Research