

PEER REVIEW HISTORY

BMJ Open publishes all reviews undertaken for accepted manuscripts. Reviewers are asked to complete a checklist review form (<http://bmjopen.bmj.com/site/about/resources/checklist.pdf>) and are provided with free text boxes to elaborate on their assessment. These free text comments are reproduced below.

ARTICLE DETAILS

TITLE (PROVISIONAL)	Physical Activity and Concussion Risk in Youth Ice Hockey Players: pooled prospective injury surveillance cohorts from Canada
AUTHORS	Blake, Tracy; Doyle-Baker, Patricia; Brooks, Brian; Palacios-Derflinger, Luz; Emery, Carolyn

VERSION 1 – REVIEW

REVIEWER	David Howell Children's Hospital Colorado and University of Colorado School of Medicine, Aurora, CO, USA
REVIEW RETURNED	26-Mar-2018

GENERAL COMMENTS	<p>Manuscript number: bmjopen-2018-022735 Title: Physical Activity and Concussion Risk in Youth Ice Hockey Players This study examined the association between physical activity volume recommendations and concussion rates among male youth ice hockey players. Design: prospective cohort study Hypothesis: none stated. Subjects: 1208 male youth ice hockey athletes (?) Primary results: There was a higher incidence of concussion among male youth ice hockey athletes who did not participate in 42 hours or more of physical activity in the 6 weeks prior to study entry (the physical activity recommendation from Canadian Society of Exercise Physiology and Public Health).</p> <p>Overall, this is a clearly written study about potential risk factors for concussion with large potential impact for public health and for future studies. The design is novel, with a novel result that physical activity volume is associated with concussion incidence, which to this point has not been investigated. There are many merits within the findings and given the study design and interpretation, the overall impact of the manuscript is high. There are a few comments about the manuscript itself, provided below, which are each relatively minor and relate more to clarification on how the study was conducted.</p> <p>Specific comments:</p> <p>Abstract: please define PA within the body of the abstract. Please provide the total N used in the current study. Currently, it appears that the authors analyzed data that started from 1726, but removed 1208 subjects. This would result in a total N of 518, but it is not intuitive to read within the context of the abstract alone.</p> <p>The introduction is well written. However, the rationale for the link between more physical activity and concussion risk is not well</p>
-------------------------	---

	<p>established. Although it is intuitive, the entire rationale seems based primarily on the work of a single study. How do the findings of Hislop and colleagues, who investigated a 20-minute warmup program to prevent concussions, relate to physical activity during daily life? Is it that extra activity provides a beneficial effect, as the Hislop study may have indicated? Or, is it that extra activity creates an increased exposure to head trauma and concussion?</p> <p>The methods are very well written- they are clear and concise to transparently describe the calculations involved for each cohort of participants in the study.</p> <p>As written previously regarding the abstract, the participant numbers are not necessarily intuitive. In the abstract it states that 1208 patients were excluded, but the way page 10 is written, it appears that 1208 players were included in the final dataset, which also aligns with Figure 1. Please correct this apparent discrepancy.</p> <p>The results are well thought out and intuitive. It was quite easy to follow along.</p> <p>Page 21- discussion paragraph 1: What, specifically, are the authors referring to when they state that the findings indicate “novel avenues for collaboration”? Does this refer to a potential concussion prevention strategy that involves more physical activity? The data agree with this notion, but how does “more self-reported physical activity” relate to a specific intervention strategy?</p> <p>Page 22, line 24: what specifically about sample size, resource allocation, and potential outcome do the results of this study provide? This is a fairly general statement with no clear tie into the results presented.</p> <p>Page 24: conclusion: I would suggest adding a statement about the directionality of the findings, rather than simply stating that the relationship between PA volume and higher concussion rates were influenced by age and competition level.</p>
REVIEWER	Cynthia LaBella Northwestern university's Feinberg school of medicine, Ann & Robert h Lurie children's hospital if Chicago
REVIEW RETURNED	07-Apr-2018
GENERAL COMMENTS	<p>Would be helpful to see the questions in the PAHQ and AHQ and for the authors to state how these were similar/different.</p> <p>Would be good to add to limitations:</p> <ol style="list-style-type: none"> 1. That all PA hrs are not equal, especially given the intermittent start and stop pattern for many sports practices and games. 2. Was it verified somehow that the extenally diagnosed concussions were diagnosed according to Betline consensus guidelines? 3. PA was evaluated as a categorical variable (yes/no) rather than continuous. I suspect there is not much difference between a player who had 41 hrs vs one who had 42 hrs. <p>Finally, would be good o have a sentence or two to comment on the implications of these findings being that players who are more</p>

	"physically fit" may be at lower risk for concussion.
--	---

VERSION 1 – AUTHOR RESPONSE

Reviewer one (Dr. Howell):

Comment 1: Abstract: please define PA within the body of the abstract.

Response 1: The objective now reads as follows: "To examine the association between meeting physical activity (PA) volume recommendations and concussion rates in 11- to -17-year-old male ice hockey players."

Comment 2: Please provide the total N used in the current study. Currently, it appears that the authors analyzed data that started from 1726, but removed 1208 subjects. This would result in a total N of 518, but it is not intuitive to read within the context of the abstract alone.

Response 2: The sentence has been revised to the following, "A total of 1208 players were included after the exclusion criteria were applied (i.e., players with unhealed injuries within six weeks of study entry, missing six-week PA history questionnaires, missing total or practice participation exposure hours, players who sustained concussions when no participation exposure hours were collected)." We made some additional edits to the abstract in order to stay within the 300-word count limit.

Comment 3: The introduction is well written. However, the rationale for the link between more physical activity and concussion risk is not well established. Although it is intuitive, the entire rationale seems based primarily on the work of a single study. How do the findings of Hislop and colleagues, who investigated a 20-minute warmup program to prevent concussions, relate to physical activity during daily life? Is it that extra activity provides a beneficial effect, as the Hislop study may have indicated? Or, is it that extra activity creates an increased exposure to head trauma and concussion?

Response 3: This is the first known investigation to explore the link between physical activity and concussion risk. The introduction has been revised to better reflect this gap in the literature:

"There is a significant body of evidence to suggest that PA may contribute to injury risk reduction in pediatric populations.⁶⁻⁸ There is an absence of literature, however, regarding the relationship between public health PA recommendations and injury, in any population.⁹

Identifying modifiable determinants of concussion is key to primary concussion prevention, but there are only two known studies that explore PA in this context^{9 10}, only one of which included pediatric participants.⁹"

Comment 4: The methods are very well written- they are clear and concise to transparently describe the calculations involved for each cohort of participants in the study.

Response 4: Thank you.

Comment 5: As written previously regarding the abstract, the participant numbers are not necessarily intuitive. In the abstract it states that 1208 patients were excluded, but the way page 10 is written, it appears that 1208 players were included in the final dataset, which also aligns with Figure 1. Please correct this apparent discrepancy.

Response 5: As shown above, the abstract has been revised to clarify the sample population.

Comment 6: The results are well thought out and intuitive. It was quite easy to follow along.

Response 6: Thank you.

Comment 7: Page 21- discussion paragraph 1: What, specifically, are the authors referring to when they state that the findings indicate “novel avenues for collaboration”? Does this refer to a potential concussion prevention strategy that involves more physical activity? The data agree with this notion, but how does “more self-reported physical activity” relate to a specific intervention strategy?

Response 7: We believe that, while this study demonstrates the exciting potential of future research examining physical activity from a primary concussion prevention perspective, it is not as yet at the stage where specific intervention strategies are warranted. The sentence was revised to provide a little more clarity, to the following:

“These findings illustrate proof of concept for the inclusion of PA metrics in future primary concussion prevention research and implementation initiatives.”

Comment 8: Page 22, line 24: what specifically about sample size, resource allocation, and potential outcome do the results of this study provide? This is a fairly general statement with no clear tie into the results presented.

Response 8: This sentence has been removed.

Comment 9: Page 24: conclusion: I would suggest adding a statement about the directionality of the findings, rather than simply stating that the relationship between PA volume and higher concussion rates were influenced by age and competition level.

Response 9: The first sentence of the conclusion has been revised to the following:

“Male Pee Wee, Bantam, and non-elite level ice hockey players who did not meet the Canadian PA volume recommendations had rates of concussion more than twice that of their counterparts who met the Canadian PA volume recommendations. This relationship was not observed amongst Midget or elite players. Concussion history was not found to significantly influence the relationship between PA volume recommendations and concussion rates in male ice hockey players.”

Reviewer two (Dr. LaBella):

Comment 1: Please leave your comments for the authors below

Would be helpful to see the questions in the PAHQ and AHQ and for the authors to state how these were similar/different.

Response 1: The PAHQ and AHQ have been added as supplementary documents. The description of the sole difference between the two forms is in the following statement, “For players who completed the PAHQ, the hours of participation for extracurricular sports were summed, and then multiplied by six to produce an estimate of six-week total extracurricular sport participation hours. For those players who completed the AHQ, the product of the hours per week and number of weeks was estimated for each sport.” (Page 7, line 29-40 of original submission).

Comment 2: Would be good to add to limitations:

Comment 2A. That all PA hrs are not equal, especially given the intermittent start and stop pattern for many sports practices and games.

Response 2A: We agree with this limitation. We believe this is addressed in the limitation section related to the need for more comprehensive PA capture on page 24, lines 15-24 of the original submission, which reads as follows:

“While these findings are compelling, this investigation is not a comprehensive PA participation evaluation. PA involving transportation (e.g., biking to school), occupation (e.g., lifeguarding), or chores (e.g., dog walking) was not captured in these data. In addition to a more comprehensive PA volume capture, PA intensity and sedentary behaviour data framed within the public health recommendations and evaluated with respect to their influence on concussion risk are needed.”

Comment 2B. Was it verified somehow that the externally diagnosed concussions were diagnosed according to Betline consensus guidelines?

Response 2B: We went back to the data to try and identify who was seen by study staff. The following was added to the results:

“Six of the 93 individuals who sustained a concussion (6.45%) were not seen by study staff [Pee Wee, has a previous history of concussion, did not meet the PA recommendations (n=1); Midget, has a previous history of concussion, met the PA recommendations (n=1); Midget, no concussion history, met the PA recommendations (n=3); Midget, no concussion history, did not meet PA recommendations (n=1)].”

The discussion was revised to include the following:

“This may have occurred regardless of whether or not the PA volume recommendations were met, resulting in non-differential misclassification errors that bias the results towards the null. The diagnostic criteria for the six participants managed by physicians is unknown. Thus, it is possible individuals who did not meet the ICCS concussion definition may have been misclassified as having sustained a concussion. The distribution of these participants would result in differential misclassification errors that would bias those findings towards the null in the age group and concussion history analyses. As only one participant was included in the level of competition analyses, the misclassification error would be non-differential, while any resulting bias towards the null would likely be minimal.”

Comment C3. PA was evaluated as a categorical variable (yes/no) rather than continuous. I suspect there is not much difference between a player who had 41 hrs vs one who had 42 hrs.

Response 2C: While this may be true, the objective of this specific study was to evaluate meeting the public health recommendations, which resulted in the dichotomization at 42 hours. The risk associated with PA volume as a continuous variable was beyond the scope of this objective.

Comment 3: Finally, would be good to have a sentence or two to comment on the implications of these findings being that players who are more "physically fit" may be at lower risk for concussion.

Response 3: Unfortunately, self-reported PA volume is not an adequate proxy of physical fitness for us to make this assertion in this investigation. Future studies should include more comprehensive PA participation and fitness capture are important to further address this limitation.

VERSION 2 – REVIEW

REVIEWER	David Howell University of Colorado School of Medicine, Children's Hospital Colorado, United States of America
REVIEW RETURNED	12-Jun-2018
GENERAL COMMENTS	The authors have done a great job at improving the clarity of their findings. I have no further comments and recommend for acceptance. Thank you for the opportunity to review this work.
REVIEWER	Cynthia LaBella Northwestern University Feinberg School of Medicine
REVIEW RETURNED	12-Jun-2018
GENERAL COMMENTS	The authors did a very nice job addressing the reviewer concerns. For my last two comments regarding PA as a categorical variable and the relationship between PA and physical fitness: It would be good for the authors to add these two topics to the limitations paragraph

VERSION 2 – AUTHOR RESPONSE

Thank you to the reviewers for your feedback, and to the editors for the provisional acceptance of this manuscript.

In response to Dr. LaBella's feedback (i.e., "For my last two comments regarding PA as a categorical variable and the relationship between PA and physical fitness: It would be good for the authors to add these two topics to the limitations paragraph."), the following sentences have been added to the limitations section (page 24). "The concussion risk associated with PA as a continuous variable cannot be extrapolated from these findings. PA volume in isolation is not a proxy for physical fitness, so the results of this investigation cannot not be used to infer a relationship between concussion risk and the participants' physical fitness."

As per the editorial staff's recommendation, I have reviewed the manuscript again and made minor changes to the language throughout the abstract and manuscript to improve flow, clarity, and consistency, added a missing reference, and corrected a citation that was misnumbered.