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Manuscript title: Comparing habit-behaviour relationships for organised sport versus leisure time physical activity

Dear Editor,

Please find attached the revised version of our manuscript titled: "Comparing habit-behaviour relationships for organised sport versus leisure time physical activity".

We are thankful for the reviewers' comments as they significantly contributed to improving the overall quality of the manuscript.

Please find below our point-by-point responses. Comments from the reviewers are in bold font, our responses are in regular font, quotes from the manuscript are in italic font, and each change made to the manuscript is in blue font.

Best regards,

The authors

Editor Comments:

I have received two reviews of your manuscript and, as you can see, both found the topic relevant and that your work is a good addition to the current literature. However, they both raise some issues regarding the use of/distinction between "sport" and "leisure" time physical activity in the context of your study.

Please revise the manuscript based on the reviewers' comments as well as those below:

1. Consider mentioning the data analyses you applied in the abstract

Response: We have included more details of the analyses in the revised abstract:

Page 2 (Abstract)

"Participants (N = 120; M age = 25 years, 75% female) who reported engaging in organised sport separately reported their habit strength for organised sport and leisure time physical activity as well as the time they spent engaging in these physical activity behaviours. Means comparisons and multilevel modelling revealed that people had significantly stronger habit for organised sport than for leisure time physical activity. Crucially, no significant difference was found in the magnitude of the sport-habit and leisure-habit link. Post-hoc analyses revealed that habit was stronger for team sport compared to individual sport, but that there was no significant difference in sport-habit association between team and individual sports."

2. Page 1, line 1: "Diseases" instead of "disease"?

Response: We have made the correction. Thank you.

Page 3 (Introduction)

"Tackling major non-communicable diseases is of global importance for reducing mortality and providing better health outcomes for individuals of all ages (Guthold et al., 2018)."

3. Page 1, line 52: Using the word "strength" twice sounds odd; are you sure this makes sense? Otherwise please rephrase.

Response: We have made this change here and removed excess use of strength a few other times throughout the manuscript as well.

Page 4 (Introduction)

"Based on the theoretical premise that cue-behaviour consistency is essential for the development of habit, it could be expected that leisure time physical activity may be less susceptible to habit formation than organised sport physical activity. Although there may be anticipated differences in the overall strength of leisure time vs organised sport physical activity habit, there is no theoretical premise to suggest that habit has a different level of influence on different types of physical activity behaviour. Although in line with habit theory, these notions have never before been tested."

4. Page 4, lines 23-24: The names of the ethical committees are named later under Acknowledgements so no need to mask them here I guess

Response: We have included the ethics committee names and details in the revised manuscript:

Page 4 (Methods - Procedures)

"All study procedures were approved by the institutions' ethical boards prior to the study UK (MRSU-20/21-21217), US (Protocol 21-178), Australia (Central Queensland University's Human Research Ethics Committee, Project #22643) and Switzerland (CCER-2019-00065)."

- 5. Following up on the previous comment: Please check the first sentence "This is your acknowledgements", I guess it was placed there by mistake. Please delete it.**

Response: The manuscript has been amended. Thank you.

- 6. Also, I don't think naming the names of the ethics committees should be placed in the Acknowledgements. Just in the Methods section would suffice.**

Response: The ethics have been removed from the acknowledgements section.

- 7. Page 4, lines 27-31: Please provide a more thorough explanation about the sample size calculation. For example, clarify which outcome you based it on and provide concrete data/examples of "the range of the variability of habit-physical activity associations found in previous research".**

Response: Our apologies on the confusing description. We have revised it:

Page 4 (Methods - Participants)

"An a priori power analysis was conducted to determine what sample size would be needed to find small-medium sized mean differences in habit strength between organised sport and leisure time physical activity (Champley, 2020). The analyses revealed that for a paired sample t-test, a study with at least 84 participants would be sufficiently powered ($1 - \beta = 95$) for a mean difference = .40. at a significance level of .05. The anticipated mean difference was based on the range of values of physical activity habit strength found in past research (Gardner et al., 2011; Rebar et al., 2016)."

- 8. Page 4, lines 37-44: I found this part rather confusing. I think some numbers don't add up. For example, the percentage of males and females. In addition, there is a discrepancy between the numbers presented here and in the abstract. The results are reported for participants that did not engage in sports although in line 35-36 it states that those participants were excluded from the analyses. Please clarify.**

Response: We have revised the description both in Methods and Results to make it clearer what numbers referred to the larger project dataset and the sample used for these analyses. All the numbers have been checked.

Page 5 (Methods - Participants)

"Data from 308 participants who provided consent for the final study were used. To be included in the study, participants were to be aged 18 years or older (16 years or older for the UK), and self-reported engaging in organised sport. However, given the aim of the analyses for this study was to compare habit strength of sport and leisure-time physical activity within-person, participants were excluded if they did not report practicing sport in a club or competition."

Page 6 (Results – Sample characteristics)

“The final analysed sample included 120 participants who reported being involved with organised sport (M age=25.62, SD= 5.51). Most (75%) of the sample were aged 21 years or older. Slightly more than half of the sample (55%) identified as male. Most (75%) of the sample were aged 21 years or older, and 55% were male (n = 66; 43% female, n = 52; 2% not disclose), n =2). Compared to the full sample of N = 308, those who engaged in organised sport (and thus were eligible for inclusion in this analysis) were more likely to be male $\chi^2 = 210,86, p < .01$. There was no difference in age or leisure time physical activity habit strength between those who did and did not engage in organised sport (p 's > .05). Those who engaged in organised sport had significantly stronger leisure time physical activity habit strength than those who did not (M difference 95% CI = 0.36 to 1.02), but there was no difference in leisure time physical activity ($p = .19$).”

9. In general, please refrain from presenting any results in the Methods section.

Response: As requested, we have moved sample characteristics and comparisons of the analysed sample to that of the larger study sample to the Results section.

10. Page 5, lines 30-31. Please clarify exactly what the “models” were and what the “evidence” was. I suggest to move this part to the Results section.

Response: We revised the analyses section to put the model descriptions first, followed by discussion of assumption testing to avoid referring to models that had yet to be defined in text.

Page 5 (Methods – Data management and analyses)

“To test the first hypothesis that people would have stronger habit for organised sport behaviour than for leisure time physical activity, a paired samples t-test was conducted. To test the second hypothesis that the association between people’s organised sport behaviour and sport habit would be stronger than the association between people’s leisure time physical activity habit and leisure time physical activity behaviour, moderation analysis within a multi-level model was conducted (Bates et al., 2015). Specifically, the data were structured to have ‘modality’ (i.e., leisure time vs organised sport) as a nested variable within-person. The model was set with time spent in behaviour as the dependent variable, with habit strength, modality, and the mean-centred interaction term between modality and habit strength as predictors. After random effect structure testing to find the best fit for the data, random effects were set so that slopes and intercepts were allowed to vary between individuals. Age, gender, and study language (English vs French) were also included as covariates. Estimated marginal means were calculated to determine the habit-behaviour slopes for the separate modalities (Lenth, 2021). Prior to and throughout the model estimations, assumption testing was conducted with all assumptions met.”

11. Table 1: Please explain (e.g. in the “note” below the table) what the numbers “2. , 3., 4. and 5” in the column headings mean.

Response: The numbers of the columns coincide with the variable names presented in the rows. This is standard practice when presenting correlation matrices. So, we are not sure we need to add some additional information.

12. Page 6, lines 20-21: There seems to be a discrepancy between the CI values here and the values in the table. Please clarify.

Response: The confidence intervals in the Table refer to the effects of each variable on the outcome, whereas those presented in Results text refer to the post-hoc estimated marginal means comparisons. We revised the Results section text to clarify this.

Page 6 (Results – Habit Strength for Leisure Time Physical Activity and Organised Sport)

“The [post-hoc](#) estimated marginal means analyses revealed that for leisure time physical activity, the behaviour-habit slope estimate was 26.00 [95% CI = 18.99 to 33.00], demonstrating a significant, positive association between habit and behaviour, and for [organised](#) sport physical activity, the behaviour-habit slope estimate was 18.70 [95% CI = 5.54 to 31.90], also demonstrating a significant, positive association between habit and behaviour. The slopes did not significantly differ from one another in magnitude (t -value = 0.99, p = .32). Notably, there were no significant age, gender, or study language effects on behaviour.”

13. Page 7, line 1: You use a different reference here for the same statement made in the Introduction (for which several other references were used). Could you please clarify the rationale/differences?

Response: The sentence referred to in the Discussion is: *“Habit is understood to be a precursor for long-term behavioural maintenance (Lally et al., 2011) and has been established as an important motivational factor of physical activity (Hagger, 2019; Rebar, 2017).”* In the introduction, habit is introduced as a construct and behavioural determinant, but the point about the importance of habit for behaviour change maintenance isn’t raised until the Discussion, thus the different citation.

14. Page 7, lines 20-21: It would be helpful if you could provide some examples.

Response: We have revised the sentence to provide examples.

Page 8 (Discussion)

“Alternative explanations for the difference in habit strength between [organised](#) sport and leisure time physical activity should also be explored including the intrinsic motivation for the behaviour, investment, and [strict scheduling](#). Given that [habit strength was stronger for team vs individual sport](#), it could be speculated that [social mechanisms could be at play such as social connectedness or accountability](#).”

Reviewer #1 Comments:

Overall, the authors of the manuscript address a relevant topic on comparing habit-behavior relationships and offer important insights for further research. Thank you at this point for addressing the issue. One thing that remains unclear to me is the differentiation and rationale for the distinction between sport physical activity and leisure time physical activity. In the manuscript, the terms are not used in a completely constant way. To bring clarity, I would suggest to revise this point mainly in the manuscript. Furthermore, I have only minor suggestions for a potential revision of the manuscript.

Response: We appreciate the points raised by the reviewer and have clarified the distinction between modalities as the organised nature of the modalities of activity, in line with the measures applied.

Introduction

- 1. I would suggest deleting the subheadings in the introduction or continuing them continuously in the introduction.**

Response: We removed the subheading within the Introduction, except for 'The Present Study' so that readers could easily access the aims and hypotheses.

- 2. The distinction of the definitions to leisure physical activity and sport physical activity is a bit vague. In my understanding, running and jogging are not defined as non-sport related physical activity. In addition, these activities can be just as competitive (even during leisure time). I would prefer a more current definition of leisure time physical activity.**

Response: In this study, the distinction was organised (club or competitive) sport vs physical activity other than those done in organised contexts. To clarify this throughout the manuscript, the term 'organised sport' has been used throughout the revision. For the sake of brevity, these changes are not included in the response letter.

- 3. Are everyday activities, such as cycling, walking, housework, etc., also included in leisure time physical activity? This point could be further delineated in the definition.**

Response: For the measure of leisure time habit strength and behaviour, participants were specifically asked about physical activity of moderate or vigorous intensity done in their leisure time, but not to include time spent being active moving from one place to another (e.g., transport), nor time spent playing sport in a club or competitively. The information was presented in the measure section.

Page 5 (Methods - Measures)

"For leisure time physical activity, participants were asked to self-report the amount of time (per week in minutes) spent completing "moderate to vigorous physical activities during free time", with moderate activities described as those which "require moderate

physical effort and make you breathe somewhat harder than normal”, and vigorous activities those which “take hard physical effort and make you breath somewhat harder than normal”. Participants were asked not to include time spent being active moving from one place to another (e.g., transport), nor time spent playing sport in a club or competitively. We used the time spent in min per week in both moderate and vigorous physical activity as the outcome.”

4. Is there a reference for the sentence page 3, line 47?

Response: Given that this sentence is speculative about the unstructured nature of leisure-time physical activity, no citation was included.

5. To classify the results, it might be useful to state the hypotheses (1 and 2) here (page 4, line 3).

Response: As recommended, we revised the Results to reiterate the study hypotheses.

Page 6 (Results -Habit Strength for Leisure Time Physical Activity and Organised Sport)

“It was hypothesised that participants would have stronger organised sports habits than leisure time physical activity habits. Consistent with H1, the paired t-test revealed that participants had stronger habits for organised sport (M = 4.30) than for leisure time physical activity (M = 3.89), [95% CI = 0.17 to 0.64], t(119)= 3.45, p < .01. It was also hypothesised that the strength of the association between habit strength and behaviour would not significantly differ between organised sport and leisure time physical activity (H2). The multilevel modelling results are depicted in Table 2, revealing that the H2 was not supported – there was no statistically significant difference in the habit-behaviour link between sport and leisure time modalities.”

6. Considering the inclusion criteria, sports activity is equated with competitive sports activity. In this case, would it be reasonable to use the term competitive sport activity instead of sport physical activity in the title and in the text?

Response: The measure mentions competitive or club-based sport activity, so we have revised the wording throughout the manuscript to be ‘organised sport’ including in the title.

7. I would suggest to briefly describe the study design under methods.

Response: We have included description of the study design within the Procedures section of the manuscript.

Page 4 (Methods - Procedures)

“Data for this cross-sectional survey study were collected from the UK, USA, Australia, and Switzerland in 2020. Participants were recruited through email lists, social media posts, and student participant pools. The survey was open to all participants who had access to a PC or laptop and were older than 18 years, with the exception that it was open to those 16 years or older in the United Kingdom. Participants in the United Kingdom, United States, and Australia who completed the study were offered a gift voucher worth £7, US \$10, and AU\$10, respectively. Participants in Switzerland were

instead offered course credit for participation. Participants were provided with a link to the survey to provide informed consent and participate in the study. The study was hosted on Inquisit Millisecond 6.2® in English (United Kingdom, United States, and Australia) and French (Switzerland). All study procedures were approved by the institutions' ethical boards prior to the study UK (MRSU-20/21-21217), US (Protocol 21-178), Australia (Central Queensland University's Human Research Ethics Committee, Project #22643) and Switzerland (CCER-2019-00065)."

8. Would you please explain how the Self-Report Behavioural Automaticity Index is suitable to measure Leisure time physical activity and sport habit strength according to the definition given in the introduction? Has the index been adapted for this study?

Response: The index is designed (and has been used extensively) to assess an assortment of behaviours by using different item stems. For example, the scale has items such as: "[the behaviour] is something I do automatically". We followed best practice to align the wording of the stem for the measure with the wording used in the outcome measure of behaviour.

9. Were the questionnaires translated into French?

Response: All major questionnaires (i.e., self-reported behavioural automaticity index and physical activity measures) were also available in French.

10. In my opinion, the chapters on discussion, limitations and conclusion are very well done. The manuscript is well written.

Response: We appreciate the comment.

Reviewer #2 Comments:

Thank you for the opportunity to review this article. I think this a great addition to the current research regarding the habit-behavior relationship and helps to understand regarding physical activity modalities and habits. Please see the few suggestions below.

1. p. 1, l. 17-20: **Maybe the authors could demonstrate their habit definition on a physical activity example?**

Response: We have added examples of how both sport and leisure physical activity behaviour may become habitual.

Page 3 (Introduction)

“After regularly engaging in the same physical activity within the same context, a person can develop strong physical activity habits. For example, if every Sunday afternoon, a person participates in a neighbourhood basketball game, the decision of whether to participate in the game each week becomes less of a deliberation and more of a habitual, automatic response. Similarly, if a person routinely walks their dog each morning after breakfast, this can become habitual response over time, resulting in more consistent engagement in that leisure time physical activity behaviour over the long-term.”

2. p. 3, l. 37: **Here, you refer to competitive clearly as team sports with your examples. However, based upon your measures, I’m wondering what people were supposed to answer that engaged in sports club activity that was not play-related since all the examples you mentioned for free time activities – running, hiking, jogging – can also be done in a sports club. Vice versa, any team sport activity can be done outside a sport club – e.g., meeting for tennis with a friend on a tennis court or meeting with some friends for beach volleyball at a public open space. Since, from my understanding, the organization form of the physical activity was your main interest, you may want to consider rephrasing it into organized and unorganized physical activity or exercise.**

Response: We appreciate the points being made here. We’re wary of changing the terminology of sport vs leisure time physical activity because that is the specified language used in the measures. However, to mitigate some of this concern, we have replaced the wording of ‘competitive sport’ throughout the manuscript with ‘organised sport.’ For the sake of brevity, these changes are not included in the response letter.

3. **Related to this, I think you could make a clearer case in the introduction regarding the mechanisms on the differences between leisure time physical activity and sporting behavior. Based upon your team-sports examples for sports activity vs. single sport behavior for leisure-time physical activity, it is not quite clear if you assume that the mechanisms are due to the organized character and / or due to the higher commitment coming with engaging in team sports. I could see that these are two different mechanisms – e.g., when meeting with friends for playing volleyball during leisure time, I could also see some of the mechanisms that help building a**

habit, as I could see it if someone signs up for running at a sports club. Since it looks like you some information on the specific sport type activity that was done, it would be informative to see how many people engaged in team vs. single sport activity for sports / competition.

Response: We appreciate the recommendation and have added the recommended post-hoc analyses results into the revised manuscript.

Page 7 (Results - Post-Hoc Analysis: Habit Strength for Team vs Individual Sport)

“After regularly engaging in the same physical activity within the same context, a person can develop strong physical activity habits. For example, if every Sunday afternoon, a person participates in a neighbourhood basketball game, the decision of whether to participate in the game each week becomes less of a deliberation and more of a habitual, automatic response. Similarly, if a person routinely walks their dog each morning after breakfast, this can become habitual response over time, resulting in more consistent engagement in that leisure time physical activity behaviour over the long-term.”

Table 3 - Results of Simple Linear Regression Analysis Testing Whether the Association between Habit Strength and Behaviour Differs Between Team vs Individual Sport

	<i>b</i>	95% Confidence Interval
Intercept	161.63*	114.90 to 208.37
Habit strength	0.31*	0.13 to 0.50
Team vs individual sport (with individual as reference)	7.17	-11.23 to 25.57
Habit × team vs individual sport	0.08	-0.22 to 0.40
Age	-2.07*	-3.81 to -0.33
Gender (with male as reference)	14.61	-4.12 to 33.35
Survey language (with English as reference)	-53.89*	-28.85 to -78.92

Note: * $p < .05$; Adj. $R^2 = 0.28$, $p < .01$

Additional revisions were made throughout the Discussion to incorporate these findings. Also, please see the added Table 3 for statistical values of model.

Page 7 (Discussion)

“Post-hoc analyses further support these claims revealing that the link between habit strength and behaviour did not differ as a function of team vs individual sport, but that people tended to have stronger habits for team vs individual sports.”

Page 8 (Discussion)

“Alternative explanations for the difference in habit strength between organised sport and leisure time physical activity should also be explored including the intrinsic motivation for the behaviour, investment, and strict scheduling. Given that habit strength was stronger for team vs individual sport, it could be speculated that social mechanisms could be at play such as social connectedness or accountability.”

Page 9 (Discussion - Conclusion)

“Additionally, team sport habits tend to be stronger than individual sport habits, but again the link between organised sport behaviour and habit do not differ between sports. Work is needed to understand what makes team-based sport activity inherently ‘habit-friendly’,

and to encourage performance of other physical activities in a way that is equally conducive to habit formation.”

- 4. Also building upon the leisure vs. sports and team vs. single modalities, it may be useful for the reader to add a point on that for future research directions to further distinguish between exercise / physical activity being done alone or with others since the commitment may be similar across the two modalities as soon as other people are involved.**

Response: Given our additional set of analyses addressing this point, we have included consideration for those findings to this point in the Discussion (please see response to previous comment).