Author’s response to reviews

Title: The subject-dependent, cumulative, and recency association of aerobic fitness with academic performance in Taiwanese junior high school students

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Author’s response to reviews:

Dear Associate Editor Dr. Tsai, and the three reviewers,

Thank you very much for your comments. We have provided point-by-point responses to each of the issues raised by reviewers 1 and 3. To more easily identify revisions made in response to particular reviewer’s comments, we have used yellow for reviewer 1 and blue for reviewer 3. Also, the manuscript has been edited by a native English speaker, as recommended by reviewer 2.

We believe the manuscript is much improved as a result of the recommended changes and appreciate all of the time and consideration that went into providing us with these suggestions.

We sincerely hope that our modifications will meet with your approval and look forward to hearing from you soon.

Sincerely,

Authors
Reviewer 1: Dr. Pei-Lan Shao- Accept after minor essential revision

In this study, the authors evaluated the relationship between aerobic fitness and academic performance. The authors found aerobic fitness make positive relationship to academic performance. There are greater effects on math and science subjects than language subjects. The authors also found the relationship are with cumulative effect and recency effect. The sample sizes are large and the results are significant.

We thank you for your valuable inputs to our manuscript. The quality of manuscript has been improved after revision that based on your comments. Thank you!

1. The authors collected data of sex, BMI, and degree of urbanization as covariates. However, the authors do not describe the analysis of these factors and if they have any effect on aerobic fitness and/or academic performance. These factors also might be confounders. The authors should delineate this concern especially the effect of degree of urbanization.

We have added results of bivariate correlations between demographic variables, fitness changes, and scores in academic subjects. The three demographic variables were correlated with both fitness changes and exam scores. Thus, all of them were included as covariates in the ANCOVAs. Please see related texts in the data analysis section (line 201-204, 206-208) and the results section (line 217-222).

2. The authors dichotomized the aerobic fitness as highly-fit (top 25% in that year population) and not highly-fit. The authors also make discussion that relationship between aerobic fitness and academic performance is probably nonlinear. Therefore, the results in this study may not be generalized to the majority of the population. Evaluation of the effect of "general-fit" to academic performance is suggested.

We agree with this concern. We choose the top 25% as the cut-off point to truly reflect the idea of being ‘fit’ and the motivation of improving aerobic fitness to foster academic achievements (line 191-192). This cut-off point has been adopted elsewhere (Hsieh et al., in press). However, this decision may result in the omission of information regarding the fitness-academic performance relation in individuals with general fitness. We have expanded the original paragraph pertaining to this issue and suggest future study use multiple levels of fitness manipulation (line 314-319). Despite this limitation, our finding is informative considering the evidence of the subject-dependent, cumulative, and recency effects. We therefore consider that there is no urgent need to perform additional analysis.

3. In this study, positive association between aerobic fitness and academic performance is recognized. However, there could be confounders and causal relationship has not been established. In the end of conclusion, the authors suggest that increasing physical education in the curriculum to enhance academic performance. The association rather than causation in nature of the relationship should be explained and emphasized here.
We understand that causal relation between fitness and academic performance cannot be established by our data, that’s why we noted this issue in the limitation section (line 303-309). However, we believe this problem could have been mitigated in the current study given: (a) the fitness measures were taken some considerable time before sitting the BCTJH, and (b) a ‘dose-related’ relation between aerobic fitness and academic performance was observed, suggesting that exam performance improved in proportion to the time being aerobically fit (line 306-309). Therefore, despite the lack of strong causal inference, the current data is still able to note the importance of adding aerobic exercise to the school curriculum to foster academic performance. Yet, we welcome further discussion on this issue.

Reviewer 2: Dr. Edna Siima Majaliwa- Accept after minor essential revision

There are few grammatical errors that need to be reviewed throughout the paper.

The manuscript has been edited and underwent grammatical check by native English speaker before re-submission.

Reviewer 3: Dr. Jackeline Lobato- Major revision

This is an interesting manuscript but I have identified some elements that need either clarification or adjustment. I suggest a revision on the text to make it clear.

We thank you for taking time reviewing our manuscript as well as your informative comments. Below please find our point-by-point rely to your concerns. We hope the current format can meet with your approval. Thank you!

Background:

1. I suggest an update in your literature review. There are some new literature about this subject (2018), that can be in your manuscript, specially this systematic review: How does academic achievement relate to cardiorespiratory fitness, self-reported physical activity and objectively reported physical activity: a systematic review in children and adolescents aged 6-18 years. Marques A, Santos DA, Hillman CH, Sardinha LB. Br J Sports Med. 2018 Aug;52(16):1039.

We have updated our references in the first paragraph of Introduction, including the study from Marques et al. (2018). Please see reference 1, 2, 4, and 5.

2. The objective presented was "to examine the association between changes over a three year period in aerobic fitness and multiple measures of academic achievement at the end of the
period" (page 4, lines 111-113). I could not see this objective being reached in this manuscript. There are some statistical methods do take into account changes over a period. The authors did not use this.

We have revised the objective in a more explicit way to more appropriately reflect our study design, please see line 110-115. It should be noted that, rather than using regression analysis as many of the previous studies did, we choose a group comparison design because of the nature of the BCTJH and the school assignment system in Taiwan.

Every year, high schools in Taiwan set specific criteria expressed in terms of total score and percentile ranks, and only accepting students whose total scores and percentile ranks meet or exceed this. In general, a 1 to 2 point increase in either two of the five academic subjects is sufficient to result in a 2 to 4 points increase in total score, which could, in turn, allow entry to a school 1 to 2 places higher in the national rankings (we have added this statement on line 173-176). Therefore, group comparison design was well suited to determine how students with different fitness trajectories differed from each other in term of exam scores and gauge the practical significance (line 197-199). Furthermore, similar study design has been used by others who also focused on Taiwanese junior high school students (Chen et al., 2013; Hsieh et al., 2018) as well as students in other countries (e.g., U.S.) (London & Castrechini, 2011; Wittberg et al., 2012).

By way of contrast, it is relatively harder to see such information with regression analyses as the purpose of regression analysis is to look at how big changes in the independent variable account for changes in the dependent variable.

Methods:

1. The section "outcomes measures" (page 6, line 146) presents information about all variables. Academic achievement is the outcome measure. Aerobic fitness is the independent variable. Others variables are covariates.

   It is our neglect to use the subtitle ‘outcome measures’. We have corrected the subtitle as ‘Measurements’ (line 152).

2. There is no information about how the covariates were measured.

   Please see the third paragraph in ‘Measurements’ elaborating data collection on covariates (line 177-186).

3. Explain why you chose 25% as "highly-fit". Is there a reference?
The age- and sex-adjusted fitness norms in Taiwan classified students’ aerobic fitness as “good” if their fitness scores are above the top 25% (75th) percentile, classified as “moderate” if fitness scores are between the 50th to 74th percentiles, as “okay” if when scores are between the 25th to 49th percentiles, and as “need to improve” if their fitness scores below the 25th percentiles.

Previous study which also focused on Taiwanese junior high school students used the 25th percentile as cut-off point (Chen et al., 2013). We have adopted their rationale and modified the cut-off point in order to truly reflect the idea of being ‘fit’ and the motivation of improving aerobic fitness as a way to foster academic achievements (line 191-192). This selection has been used previously (Hsieh et al. 2018).

We are aware that this decision may result in the omission of information regarding the fitness-academic performance relation in individuals with general fitness. Despite this limitation, our finding is still informative considering the evidence of the subject-dependent, cumulative, and recency effects. We have addressed this issue in one paragraph pertaining to study limitations (line 314-319).

4. I could not understand the methods of "cumulative effect". Need more explanation. - There is a longitudinal data but the authors did not used the appropriated statistical approach to make the analyses stronger.

As noted in prior comment, we feel that group comparison design is well suited to our data considering the nature of the BCTJH and the school assignment system in Taiwan. In the current study, ‘cumulative’ effect of being aerobically fit was reflected by the length of time to stay in the ‘highly fit’ zone (i.e., all 3 years, 2 of the 3 years, 1 of the 3 years), with longer length of time representing larger cumulative effect.

Results:

I suggest writing again to make this section more informative. The authors need to interpret the principal results.

We thank you for noting this problem. We have condensed the results section and added some interpretations to enhance the readability (line 223-254).

Discussion:

I suggest including some new literature.
We have included some new literatures in the discussion section. Please see reference 25, 26, 29, 31-37.