# PEER REVIEW HISTORY

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## ARTICLE DETAILS

<table>
<thead>
<tr>
<th>TITLE (PROVISIONAL)</th>
<th>The association between physical activity and body fat percentage, with adjustment for BMI: a large cross-sectional analysis of UK Biobank</th>
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<tr>
<td>AUTHORS</td>
<td>Bradbury, Kathryn; Guo, Wenji; Cairns, Benjamin; Armstrong, Miranda; Key, Timothy</td>
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## VERSION 1 - REVIEW

<table>
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<tr>
<th>REVIEWER</th>
<th>A. Tamlyn Shields</th>
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<td>University of North Carolina Wilmington</td>
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<td></td>
<td>USA</td>
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<td>REVIEW RETURNED</td>
<td>03-Mar-2016</td>
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| GENERAL COMMENTS | This research is a nice addition to the literature and will appeal to a broad audience. The "no" response in regards to the methods being indicated completely results in the authors failure to indicate whether participants were given the standard pre-test instructions for body composition assessment via BIA. As these instructions can affect the accuracy of the test, whether they were provided, and whether any measures were taken to determine the degree to which participants followed them would be of interest. The other "no" indicated above is related to the statistical methods utilized. Usage of Cohen's delta would aid tremendously in interpreting the results, particularly since the "n" was so large. Cohen's delta would indicate the size of the difference, rather than simply whether the difference is statistically significant. The conclusion of the authors would be better supported if Cohen's delta was included as part of the analyses. |
| REVIEWER                        | David R. Bassett, Jr.                     |
|                                 | University of Tennessee, Knoxville       |
| REVIEW RETURNED                 | 02-May-2016                              |

| GENERAL COMMENTS | The paper has several strengths. Primarily these are the large sample size (N=259,808), and the addition of percent body fat as an additional measure of adiposity. More detail is required on the bioelectrical impedance analyzer (BIA) methods; for instance, were time of day and hydration status controlled?  

In terms of methodology, if measures of physical activity were obtained in the UK BioBank study with a wearable device, these would provide a more objective measure than the modified IPAQ short form questions. Moreover, repeat measures of physical activity would be preferable given the anecdotal reports that initial and follow-up measures were quite different. |
The results of the study indicate that BMI and percent body fat are closely related, and that there is an inverse relationship between physical activity and adiposity, although these are not entirely new findings. Other things that I found odd were that the authors focused their analysis on comparing those with <5 excess METxhours/week and those with at least 100,000 excess METxhours/week of physical activity. These are wildly divergent groups, and it would also be useful to quantify the cross-sectional relationship between physical activity and adiposity in groups that were not as extreme. I would like to see some statistical analyses run on the less divergent subgroups.

Of course, one of the advantages of using percent body fat rather than BMI as an index of adiposity is that the former takes into account the amount of fat mass and lean body mass (LBM). Given that high levels of physical activity result in oxidation of fat, and could also conceivably build muscle (or decrease age-associated loss of muscle mass), it would be interesting if the authors discussed whether or not their study show differences in the cross sectional relationships between physical activity and adiposity, depending upon which measure of adiposity was employed.

REVIEWER
Pantelis Theodoros Nikolaidis
Department of Physical and Cultural Education, Hellenic Army Academy, Athens, Greece

REVIEW RETURNED
06-May-2016

GENERAL COMMENTS

General comments
This is a very interesting study on an important topic using a very large sample and laboratory assessment methods. The authors have used correctly the scientific methods and present their findings properly using tables and figures of high quality. Given the significance of this study for health practitioners, I would recommend it for publication, but a few issues should be addressed previously. My main concern is that extremely few references (13) have been used for such a well-studied topic. I recommend adding much more references in order to add more information in the Introduction and Discussion. A recommending additional literature is the following:


- Bohn, B., Müller, M.J., Simic-Schleicher, G., Kiess, W., Siegfried, W., Oelert, M., Tuschy, S., Berghem, S., Holl, R.W. BMI or BIA: Is
body mass index or body fat mass a better predictor of cardiovascular risk in overweight or obese children and adolescents? (2015) Obesity Facts, 8 (2), pp. 156-165.


Ranasinghe, C., Gamage, P., Katulanda, P., Andraweera, N., Thilakarathne, S., Tharanga, P. Relationship between Body mass index (BMI) and body fat percentage, estimated by bioelectrical impedance, in a group of Sri Lankan adults: A cross sectional study (2013) BMC Public Health, 13 (1), art. no. 797.

Liu, P., Ma, F., Lou, H., Liu, Y. The utility of fat mass index vs. body mass index and percentage of body fat in the screening of metabolic syndrome (2013) BMC Public Health, 13 (1), art. no. 629,. Cited 13 times.


Nikolaidis, P.T. (2014): Weight status and physical fitness in female soccer players: is there an optimal BMI? Sport Sciences for Health,
| Nikolaidis, P.T. (2013): Body mass index and body fat percentage are associated with decreased physical fitness in adolescent and adult female volleyball players. Journal of Research in Medical Sciences, 18(1):22-6 |

**Specific comments**

**Introduction**

1) The Introduction is too short and has few references. The first paragraph needs to be larger
2) All the aims presented in the end of the Introduction have not introduced properly, that is, the relationship between PA with BF and BMI, and the "important lifestyle factors" must be reported in the previous paragraphs.

**Methods**

3) Statistics: The criteria for the interpretation of Pearson’s r should be presented (e.g. when it is considered small, medium...).

**Discussion**

4) A paragraph presenting limitations, strengths and practical implications before conclusions is missing.

**VERSION 1 – AUTHOR RESPONSE**

**Reviewer: 1**

**Comment 1:**

This research is a nice addition to the literature and will appeal to a broad audience. The "no" response in regards to the methods being indicated completely results form the authors failure to indicate whether participants were given the standard pre-test instructions for body composition assessment via BIA. As these instructions can affect the accuracy of the test, whether they were provided, and whether any measures were taken to determine the degree to which participants followed them would be of interest.

**Authors’ response:**

The participants were not given any specific instructions pertaining to the bioimpedance measures prior to attending the assessment centre. We have added this information to the paper (pages 6-7):

"Participants were not asked to fast, nor were they given any specific instructions pertaining to the bio-impedance measures prior to attending the assessment centre. Water was available at all times throughout the visit and visits occurred throughout the day (8am-8pm)."

We have also added in the following sentence to the discussion (page 16):
“Hydration status, exercise and food consumption can have small effects on body fat values measured by bioimpedance; had these factors been standardised between participants, we may have seen slightly stronger associations between body fat percentage and physical activity.”

Comment 2:
The other "no" indicated above is related to the statistical methods utilized. Usage of Cohen's delta would aid tremendously in interpreting the results, particularly since the "n" was so large. Cohen's delta would indicate the size of the difference, rather than simply whether the difference is statistically significant. The conclusion of the authors would be better supported if Cohen's delta was included as part of the analyses.

Authors' response:
We have reported in the paper (page 13) the size of the difference in body fat percentage, after adjusting for BMI, in participants who did <5 excess MET-hours per week compared to those who did 100 or more excess MET-hours per week. We have not presented a standardised measure of effect size, such as Cohen's delta, because we felt most readers would find it more useful to have the estimate of the difference on the body fat percentage scale. If the editor feels it is necessary to add another measure of the size of the difference, we can include the Cohen's delta.

Reviewer: 2
Comment 1:
The paper has several strengths. Primarily these are the large sample size (N=259,808), and the addition of percent body fat as an additional measure of adiposity. More detail is required on the bioelectrical impedance analyzer (BIA) methods; for instance, were time of day and hydration status controlled?

Authors' response:
See response to comment 1 from reviewer 1.

Comment 2:
In terms of methodology, if measures of physical activity were obtained in the UK Biobank study with a wearable device, these would provide a more objective measure than the modified IPAQ short form questions. Moreover, repeat measures of physical activity would be preferable given the anecdotal reports that initial and follow-up measures were quite different.

Authors' response:
UK Biobank has collected accelerometer data, however only on a sub-sample of approximately 100,000 participants and currently only the raw data is accessible, thus it is unfortunately not able to be used in the current paper. The same physical activity questionnaire was administered on approximately 20,000 participants in UK Biobank about 5 years after recruitment. The responses to the 2nd questionnaire show regression to the mean and we use this information to help interpret baseline physical activity.

Comment 3:
The results of the study indicate that BMI and percent body fat are closely related, and that there is an inverse relationship between physical activity and adiposity, although these are not entirely new findings. Other things that I found odd were that the authors focused their analysis on comparing those with < 5 excess METxhours/week and those with at least 100,000 excess METxhours/week of
physical activity. These are wildly divergent groups, and it would also be useful to quantify the cross-sectional relationship between physical activity and adiposity in groups that were not as extreme. I would like to see some statistical analyses run on the less divergent subgroups.

Authors’ response:

It is not possible to give pairwise comparisons between every group, and if we did not use the extreme categories we would have to arbitrarily choose another two categories to compare. We have presented the numbers that correspond to Figure 4 in Supplementary Tables 3 and 4, from which other pairwise comparisons can be derived. Also, although <5 excess MET-hours and 100 or more excess MET-hours seems quite a large difference, the re-measurement of a sub-sample 5 years later indicates that the average physical activity in these groups was approximately 12 excess MET-hours and 82 excess MET-hours, respectively.

Comment 4:
Of course, one of the advantages of using percent body fat rather than BMI as an index of adiposity is that the former takes into account the amount of fat mass and lean body mass (LBM). Given that high levels of physical activity result in oxidation of fat, and could also conceivably build muscle (or decrease age-associated loss of muscle mass), it would be interesting if the authors discussed whether or not their study show differences in the cross sectional relationships between physical activity and adiposity, depending upon which measure of adiposity was employed.

Authors’ response:
We state in the first sentence of our discussion that “…more physical activity was associated with both a lower BMI and a lower body fat percentage”. We also state in the results section (page 13) that “…as shown by the r2 values, age and physical activity explained more of the variation in body fat percentage than the variation in BMI in this study population”

Reviewer: 3

General comments:
This is a very interesting study on an important topic using a very large sample and laboratory assessment methods. The authors have used correctly the scientific methods and present their findings properly using tables and figures of high quality. Given the significance of this study for health practitioners, I would recommend it for publication, but a few issues should be addressed previously. My main concern is that extremely few references (13) have been used for such a well-studied topic. I recommend adding much more references in order to add more information in the Introduction and Discussion. A recommending additional literature is the following:


Bohn, B., Müller, M.J., Simic-Schleicher, G., Kiess, W., Siegfried, W., Oelert, M., Tuschy, S.


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Nikolaidis, P.T. (2013): Body mass index and body fat percentage are associated with decreased physical fitness in adolescent and adult female volleyball players. Journal of Research in Medical...
Sciences, 18(1):22-6

Authors’ response:

We thank the reviewer for the background literature suggestions. Whilst most of them make some comparison of body fat percentage to BMI, most of the suggested articles are on very small samples, quite a few are in adolescents and/or in Asian or non-white populations, and the first 14 (out of 19) articles are not about exercise and physical activity. For example, the article by Ortega et al., comparing the associations between BMI and body fat percentage and CVD mortality, is interesting; however, our focus is on PA and adiposity, not on adiposity and disease risk, therefore Ortega et al. is not of direct relevance, but we will consider these findings if we extend our research in future to look at disease risk. The last 5 articles are about BMI and body fat percentage among athletes. We have added references to the paper, but we have focused the introduction and discussion around the novel aspect of this paper: investigating whether, in a general middle-aged population, more physical activity is associated with a lower body fat percentage, for a given BMI.

Specific comments

Introduction
1) The Introduction is too short and has few references. The first paragraph needs to be larger.

Authors’ response:

As stated in response to the previous comment, we have kept the introduction focused on the novel aspect of the paper.

2) All the aims presented in the end of the Introduction have not introduced properly, that is, the relationship between PA with BF and BMI, and the “important lifestyle factors” must be reported in the previous paragraphs.

Authors’ response:

We have removed reference to the important lifestyle factors in the introduction – this is a sensitivity analysis and does not need to be introduced here. The second paragraph of the introduction we state that “…people who do comparatively more physical activity have a lower BMI than less active people (Ref 4,5). Few large epidemiological studies have directly estimated body fatness…”

Methods
3) Statistics: The criteria for the interpretation of Pearson’s r should be presented (e.g. when it is considered small, medium…).

Authors’ response:

We have added the following to the methods section (page 9):

“Pearson’s correlation coefficients between BMI and body fat percentage were calculated; values of 0.80 or above are considered very strong, values between 0.60-0.79 strong, 0.40-0.59 moderate,
0.20-0.39 weak, and 0.00-0.19 very weak (11).

We have now also described the correlations as strong/very strong (page 12):

“The correlation between BMI and body fat percentage was very strong in women (r = 0.85), and
strong in men (r = 0.79).”

Discussion
4) A paragraph presenting limitations, strengths and practical implications before conclusions is missing.

Authors’ response:

For the discussion we have followed the order recommended by BMJ open. The 2nd paragraph of the
discussion describes the strengths and weaknesses of the study and the 4th paragraph describes the
implications of the results (i.e. that our results suggest that other studies that have adjusted for BMI,
may not have fully controlled for adiposity).

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<th>REVIEWER</th>
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<tr>
<td>UNIVERSITY OF NORTH</td>
<td>Carolina Wilmington, USA</td>
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</table>

**GENERAL COMMENTS**

This is an interesting topic. The topic has been researched considerably previously; however, this study is unusual in its size and due to combining body fat assessment with BIA. Additional reference to previous studies would have been beneficial. Providing pre-test instructions for the BIA assessment and using a more objective measure of physical activity would have greatly strengthened the study. However, objective assessment of physical activity would be difficult in a study of this size.

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<tr>
<td>EXERCISE PHYSIOLOGY LABORATORY, Nikaia,</td>
<td>Greece</td>
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**GENERAL COMMENTS**

The authors refused to consider my comments for adding more references and enhancing the discussion. Considering the widely already known conclusions of the abstract that “Conclusions: Physical activity was inversely associated with BMI and body fat percentage. For people with the same BMI, those who were more active had a lower body fat percentage.”, I cannot understand why the authors do not discuss their findings with many previous studies. I would expect from a study on such topic to use at least 30-40 references; they cannot conclude the very well known “physical activity was inversely associated with BMI and body fat percentage” without discussing this with many published studies. Thus, I suggest the rejection of the paper.
This is an interesting topic. The topic has been researched considerably previously; however, this study is unusual in its size and due to combining body fat assessment with BIA. Additional reference to previous studies would have been beneficial. Providing pre-test instructions for the BIA assessment and using a more objective measure of physical activity would have greatly strengthened the study. However, objective assessment of physical activity would be difficult in a study of this size.

Authors’ response:
In the discussion section of the manuscript we have now referred to previous studies that have shown inverse associations between physical activity and either BMI or body fat percentage (see the following response for details).

The authors refused to consider my comments for adding more references and enhancing the discussion. Considering the widely already known conclusions of the abstract that "Conclusions: Physical activity was inversely associated with BMI and body fat percentage. For people with the same BMI, those who were more active had a lower body fat percentage.", I cannot understand why the authors do not discuss their findings with many previous studies. I would expect from a study on such topic to use at least 30-40 references; they cannot conclude the very well known "physical activity was inversely associated with BMI and body fat percentage" without discussing this with many published studies. Thus, I suggest the rejection of the paper.

Authors’ response:
We appreciated the time this reviewer spent in the first round thoroughly reviewing our manuscript, however we found it difficult to revise the manuscript based on the original comments. The reviewer suggested certain sections should be longer and more references included, and although they kindly provided a list of recommended references, we were uncertain what exactly they wanted us to discuss and after extensive discussion we agreed that most of the suggested additional references were not directly relevant to the stated aims and novel aspects of our study. We agree that previous studies have shown that physical activity is inversely related to BMI and body fat percentage. In the discussion section of the manuscript we have now referred to previous small studies, mostly in young athletic populations, that have shown these associations (page 17):

"Previous small studies (n<200), in young athletic populations have found inverse relationships between measures of physical fitness and BMI and body fat percentage (14, 15)."

We have also revised the objectives and conclusions of our abstract to emphasise the large sample drawn from the general population of older (middle-aged) adults, and the novel aspect of this study is that it examines the associations between physical activity and body fat percentage after controlling for BMI.

Abstract objectives changed to:
“Objectives: The objective of this study was to examine if, in the general population, physically active adults have less body fat after taking BMI into account.”

Abstract conclusions changed to:

“Conclusions: In this sample of middle-aged adults, drawn from the general population, physical activity was inversely associated with BMI and body fat percentage. For people with the same BMI, those who were more active had a lower body fat percentage.”
Association between physical activity and body fat percentage, with adjustment for BMI: a large cross-sectional analysis of UK Biobank

Kathryn E Bradbury, Wenji Guo, Benjamin J Cairns, Miranda E G Armstrong and Timothy J Key

BMJ Open 2017 7:
doi: 10.1136/bmjopen-2016-011843

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