Author's response to reviews

Title: Body Mass Index and Measures of Body Fat for Defining Obesity and Underweight: A Cross-Sectional, Population-Based Study

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Author's response to reviews: see over
Dear Miss Carisse Reyes/Dr Ranil Jayawardena

Re: Ms 7062684351216525

Pasco J et al. Body mass index and measures of body fat for defining obesity and underweight: A cross-sectional, population-based study.

Thank you for the opportunity to submit a revised manuscript. The reviewers’ comments have been addressed and changes to the text have been shown in red. An extra table and an extra citation have been added. Responses to reviewers are detailed below this cover note.

I believe the additions have improved the manuscript and hope that it is now acceptable for publication.

Regards

Julie A. Pasco

Corresponding Author.

Response to reviewers

Referee 1

Reviewer: Masaharu Kagawa

This is a large scale study that examined appropriateness of WHO’s BMI cut-off points for underweight, overweight, and obesity by comparing agreement with percentage body fat (%BF) either measured by dual energy x-ray absorptiometry (DXA) or estimated using an equation. The results indicated that BMI is likely to underestimate individuals with large amount of fat deposition, particularly in males. Interestingly, the study also showed an underestimation of BMI for a prevalence of underweight in both genders. From the results, the authors concluded with a suggestion that an optimal gender- and age-specific threshold to define underweight obesity.

Overall, the manuscript was well presented and easy to follow. However there are a number of considerations throughout the manuscript, mainly in the methodology section. It is recommended the authors to consider issues listed below and explain more in details:

Major compulsory revisions

1. p5. There is no detailed information about sample characteristics, such as number of males and females in each age group as well as in each BMI category.
Response: The numbers of males and females in each age-group as well as in each BMI category are now displayed in Table 2. Consequently the previously existing tables, and related text references to tables, have been re-numbered.

Amendments to text:

Table 1 added.

2. p6. The current dataset is a combined data which body composition was measured using two different DXA machines (Lunar DPX-L or Prodigy Pro). Since it has been suggested that data obtained from different machines, including different version, may not be comparable. Please provide an evidence that two DXA machines provide comparable results from the measurements of same individuals.

Response: Cross-calibration of the two scanners was performed prior to decommissioning the DPX-L and no significant differences in lumbar spine or femoral neck bone mineral density were seen in dual scans performed on 40 subjects aged 21 to 82 years. We have amended the text to clarify the numbers of men scanned on each DXA. We have also performed a sensitivity analysis that excluded DPX-L measures and compared prevalence estimates of obesity derived from BMI and %BF criteria. The patterns were sustained and, importantly, significant differences persisted between prevalence estimates using the two criteria for the two age groups 20-29 years and 80+ years obesity: prevalence for age 20-29 years BMI 8.2% (95% CI 4.5, 13.4) and %BF 25.1% (95% CI 18.8, 32.3), and for age 80+ BMI 13.4% (95% CI 8.7, 19.5) and %BF 29.8% (95% CI 23.1, 37.3). We have amended the text in the methods, results and discussion sections to address this issue.

Amendments to text:

Methods page 6: Measures of body fat mass, lean mass and bone mineral content were provided by whole body dual energy x-ray absorptiometry (DXA) using a Lunar DPX-L densitometer (software version 1.31; Lunar, Madison, WI, USA); however, 923 of the men were scanned on a GE-Lunar Prodigy (Prodigy; GE Lunar, Madison, WI, USA) when the DPX-L was decommissioned. No significant differences were detected in lumbar spine or femoral neck bone mineral density measurements when the scanners were cross calibrated on 40 subjects aged 21 to 82 years.

Methods page 7: A sensitivity analysis that compared prevalence estimates of obesity derived from BMI and %BF criteria was performed after excluding men scanned on the DPX-L densitometer.

Results page 8: A sensitivity analysis that excluded men scanned on the DPX-L densitometer showed that the age-related patterns based on %BF criteria were sustained and, importantly, significant differences persisted between prevalence estimates based on BMI and %BF criteria for the two age groups 20-29 years and 80+ years obesity: prevalence for age 20-29 years BMI 8.2% (95% CI 4.5, 13.4) and %BF 25.1% (95% CI 18.8, 32.3), and for age 80+ BMI 13.4% (95% CI 8.7, 19.5) and %BF 29.8% (95% CI 23.1, 37.3).
Discussion page 12: In the absence of cross-calibration data between the two densitometers, a sensitivity analysis that restricted comparisons for men scanned on one densitometer alone showed similar patterns to the full dataset. However, we cannot exclude the possibility of differences between the two machines.

3. In the present study, body composition of 66 participants was estimated using a prediction equation. It is not appropriate to combine the body composition results obtained from actual measurements and estimation from prediction equation. Instead, the authors should exclude these 66 participants. 

Response: We agree with the reviewer’s statement and have now excluded only the individuals with without whole body scans (n=52). We retained 14 participants who had previously been excluded because their body weight exceeded 120 kg (these individuals were scanned despite their large body weight) as excluding them would have biased the prevalence estimates for obesity. The text has been modified accordingly.

As 52 individuals have been excluded, all analyses have been repeated and the amendments have been shown in red throughout the tables and text.

4. While %BF of participants was determined from the equation, an appropriateness of the equation to the study population is not known. Since the equation was derived from the same project, it appears the participants of the present study were the group of which the equation was derived from. If that was the case, it is not appropriate to use the equation to estimate body composition of the participants.

Response: Imputed values have been excluded.

Discretionary revisions

1. While the study topic is an important one, it is already well known that BMI is not a good index for obesity. Since there is a lack of strong statement on significance of conducting the present study, the authors should provide further rationale with more emphasis on reasons of focusing underweight cut-off point.

Response: This is a constructive comment and we have introduced the notion that a temporal shift in BMI in the population to greater values has reduced the proportion of those considered to be underweight. This added notion strengthens the need to investigate the prevalence of underweight using different criteria. A new citation has now been added and subsequent changes made in citation numbers in the text and in the publications list.

Amendment to text
Introduction page 4: We have previously reported a temporal shift in the distribution of BMI in the population such that the prevalence of underweight women diminished between 1993-1997 and 2004-2007, but that study did not investigate changes in body composition.

2. p4. While the authors cite references for the statement “This approach extends previous studies that utilised the World Health Organization (WHO) standard %BF values of 25% for men and 35% for obesity”, this statement is incorrect. As described in detail by other paper (Ho-Pham and Campbell, Mayo Clin Proc, 2011), WHO has not proposed any %BF cut-off points. Please revise the above statement and the rationale of the study.

Response: We thank the reviewer for this comment. The sentence has been corrected.

Amendment to text

Introduction page 4: This approach extends previous studies that utilised %BF thresholds of 25% for men and 35% for obesity.

3. p6. While the authors described a technical assistant for DXA assessments as a “trained personnel”, the authors should provide further details whether the assistant had adequate accreditation to operate the device.

Response: Densitometer operators have completed the accredited Australian and New Zealand Bone and Mineral Society (ANZBMS) Clinical Densitometry Training Course and were licenced to use radiation sources for research through the Department of Health State Government of Victoria.

Amendment to text

Methods page 6: Anthropometry was performed by trained personnel and the densitometer operators had completed the accredited Australian and New Zealand Bone and Mineral Society (ANZBMS) Clinical Densitometry Training Course and were licenced through the Department of Health State Government of Victoria to use radiation sources for research.

Referee 2

Reviewer's report

Reviewer: Anna Peeters

This article addresses a topic of importance – how well does BMI capture % body fat across age and sex groups? However, the premise of the analysis is unclear to me. If BF% cut-offs are determined based on BMI cut-offs then doesn’t the prevalence according to each measure have to be very similar if the same population is used for both purposes?
Response: The single cut-off points for BMI that define underweight, overweight and obesity have been used to determine equivalent age and sex-specific %BF values. We have highlighted the impact of using single BMI thresholds for categorising levels of body fatness without making allowances for age- and sex-specific differences in body composition.

*Further it seems strange to derive %BF from BMI rather than the other way around when body fat is the measure of interest.*

Response: BMI thresholds are well established for categorising levels of body fatness. We have used the equations only to calculate age-and sex-specific equivalence values for these thresholds.

*In addition, if the primary goal is to look at correlations between BMI and %BF it seems scientifically unsound to estimate missing %BF values using BMI.*

Response: Imputed %BF values have now been removed from the manuscript.

*The findings that such high proportions have exact agreement between BMI and %BF seem self-fulfilling given that one was derived from the other.*

Response: The BMI values and %BF values were both measured for the study participants.

*If the authors are interested to show that BMI may predict %BF less well in certain age and sex groups then I would suggest they do that instead, as this is an important message.*

Response: It was not our intention to discern how well BMI predicts %BF. Our manuscript highlights shortcomings in using single BMI thresholds for categorising levels of body fatness and we propose that age- and sex-specific cut-off values be used.

**Referee 3**

*Reviewer: Indu Waidyatilaka*

This is a well designed piece of work which addresses an area which requires to be studied. More details are required in the methodology on statistics. The description of the use of DXA for body fat analysis and in the derivation of an equation currently lacks clarity. Therefore this needs to be stated in more detail in the methodology. Although the limitations are adequately addressed, since the work pertains only to whites, it is felt that this needs to be reflected in the title and abstract and conclusions should be limited to whites. Tables need to be formatted according to the journal style. Overall a check on the tense is required.
Response: Further information about the derivation of the equation linking BMI to %BF has now been inserted in the statistical analyses section of Methods. Reference to the predominantly white population studied has been added to the abstract, methods and conclusion section of the discussion. We have not altered the title, however, as it is now clearly stated throughout the manuscript that the study participants were white.

Amendments to text

Abstract: The aim of this cross-sectional study was to identify sex-and-age-specific values for percentage body fat (%BF), measured using whole body dual energy x-ray absorptiometry (DXA), that correspond to BMI 18.5 kg/m$^2$ (threshold for underweight), 25.0 kg/m$^2$ (overweight) and 30.0 kg/m$^2$ (obesity) and compare the prevalence of underweight, overweight and obesity in the adult white Australian population using these BMI thresholds and equivalent values for %BF.

Abstract: Utilising a single BMI threshold may underestimate the true extent of obesity in the white population, particularly among men.

Introduction page 4: The aim of this study was to compare prevalence estimates for underweight, overweight and obesity in the adult white Australian population using BMI thresholds for each category and the equivalent sex-and-age-specific cut-points for %BF.

Methods (subjects) page 5: The cohort was essentially white; no indigenous Australians participated in the study.

Methods (statistical analyses) page 7: The equation had been derived previously using a subset of 1,299 men and 855 women from the Geelong Osteoporosis Study for whom whole body DXA scans provided valid measures of body fat mass. Details of the development of this equation have been described elsewhere [5].

Conclusions page 13: We report that the prevalence of obesity using a BMI threshold may underestimate the true extent of obesity in the white population, particularly among young and elderly men. We also report that for both sexes, the prevalence of underweight using a BMI threshold may underestimate the true extent in the white population.

Minor essential revisions

Methods

Paragraph on subjects - Reword to indicate that many populations were used giving dates.

Response: All participants were drawn from the same population, described by the Australian Electoral Commission as the Barwon Statistical Division. The sampling frame used was the Commonwealth electoral rolls and the dates of selection are shown for each phase of recruitment (on page 5).

Results
Paragraph two – Define middle age.

Response: The peak occurring in middle age in women has been clarified as age 50-59 years. The following sentence, which referred to a middle-age peak in men, has also been re-structured to avoid the term ‘middle age’ which has been replaced by age 60-69 years.

Amendments to text

Results (page 8): In women, both methods indicate that the prevalence of obesity increased with age until 50-59 years, followed by an age-related decline. The age-related profile for men according to BMI criteria showed an age-related increase that peaked at age 60-69 years followed by an age-related decline; however, %BF values indicate that obesity was under-estimated in younger men and elderly men than BMI would suggest.

Discussion

Paragraph one - “difference in the estimates is not significant”- this has to be first mentioned in the results.

Response: A summary of differences in age-standardised prevalence estimates for underweight, overweight and obesity, for both men and women, have been added to the Results (Prevalence of underweight, overweight and obesity) section.

Amendments to text

Results page 9: Thus, the mean age-standardised prevalence for underweight for both men and women was lower according to BMI. For men, the age-standardised prevalence for obesity was similarly lower according to BMI; for women the difference in estimates of age-standardised prevalence for obesity based on BMI and %BF was not significant. No differences were detected in age-standardised prevalence estimates for overweight in either sex.

Paragraph three – “It seems likely that for this group, body fat contributes more, and lean tissue less, to body weight than usual” – possibly better re-worded as “than in other groups”

Response: The text has been re-worded as suggested.

Amendment to text

Discussion page 11: It seems likely that for this group, body fat contributes more, and lean tissue less, to body weight than in other groups.

Paragraph five - “missing %BF values were imputed for 66 individuals” – should be detailed in methodology.

Response: Imputed values have been excluded.
Tables

Tables need to be formatted according to the journal style.

Response: The formatting has been corrected.

Discretionary revisions - indicated in the manuscript. Please refer the attached manuscript.

Response: Most changes have been implemented as suggested and alterations to the text have been indicated in red.