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Validity of adult lifetime self-reported body weight

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Abstract

Objective: To investigate the accuracy of self-reported weight status over the adult lifespan.
Design: Estimates of self-report bias were obtained from a linear regression analysis and the magnitude of the discrepancy was studied for demographic groups (based on gender, race and educational attainment), weight status, number of years from the age of the reported weight and current age of the respondent.
Subjects: A subset of 6101 individuals from the National Health and Nutrition Examination Epidemiological Follow-Up constituted the study sample.
Results: Gender, elapsed time and BMI contributed to self-report bias. Effects of gender and elapsed time were small relative to the effects of BMI, with women tending to underestimate weight by 0·82 kg (1·8 lb), men overestimating by 2·27 kg (5·0 lb) and bias increasing by 0·09 kg (0·2 lb) for each year of retrospection. Every increase of one unit in BMI was associated with an additional 0·91 kg (2·0 lb) underestimate in self-reported weight.
Conclusion: Accuracy of adult self-reported weight profiles will be greatly underestimated if samples have individuals of current or past high relative weight. Adjusting for underestimation based on the respondent's weight status alone will considerably improve the validity of weight information.

Keywords
Validity
Self-report
Obesity
Body mass index
Anthropometry
NHANES

Obesity is associated with increased risk for some of the major causes of death in developed nations[1,2]. If these findings stem from a causal relationship, one would expect that individuals with a long history of high relative weight will be at the greatest risk of morbidity and mortality due to these diet-related conditions. In directing health interventions for diet-related medical conditions, it will then be important not only to identify current overweight and obese individuals but also to determine the duration of this high relative weight over the individual's lifetime. Most surveys of health status and behaviours inquire only about the current relative weight. The NHANES I Epidemiological Follow-up Study (NHEFS) is unique in that, in addition to the question on current weight, participants were asked about weight status at several ages of their adult life, specifically ages 25, 40 and 60 years, when applicable.

While such retrospective self-reporting would be useful in determining the adult weight history of an individual, given the inaccuracies found in self-reported current weight, one might be even more doubtful of the validity of lifetime self-reported weights which potentially have the dual biases of recall and misreporting[3–5]. Direct anthropometric measurement is a possible remedy to such bias. Yet this is an expensive solution and nearly infeasible when interest is in obtaining several measures over an individual lifetime. If relative lifetime weights could be accurately obtained by a simple interview, it would be a great aid in monitoring public health. With this information interventions could appropriately target individuals at the highest risk for diet-related health problems without the additional cost and labour of direct measurement.

Examination studies are unlikely to replace self-report methods for large surveys, so it is important to identify what bias might arise in self-reported lifetime weights; and also, if present, how the bias varies by demographic group and weight status, which have been shown to contribute to systematic inaccuracies in current reported weight[6–10]. The present article undertakes this task by assessing the validity of estimated adult weight based on lifetime weight profiles obtained as part of the NHEFS.

Data and methods

The first National Health and Nutrition Examination Survey (NHANES I) was conducted between the years 1971 and 1975. The goal of this survey was to obtain information about dietary and health behaviours of a nationally representative sample of the American population. In the 1980s, it was decided to enhance the information obtained from

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this survey of nearly 32 000 individuals by conducting a follow-up. The NHEFS (NHANES I Epidemiological Follow-up Study) was completed in four batches beginning in 1982 and ending in 1992. The follow-up tried to obtain the vital status of all adults from the original NHANES I sample, identifying the cause of death for those who were deceased at the time of follow-up or obtaining current health information for those who were still alive and willing to participate in the additional study. There were 14 407 persons in the original sample whose vital status was identified in NHEFS. Complete details on the survey objectives and methods are given elsewhere[11].

A set of questions asked at follow-up concerned the lifetime weight profile. In addition to current weight, participants were asked to give their weight at ages 25, 40 and 60 years, when applicable. An individual could have participated in any of the four NHEFS follow-up attempts between 1982 and 1992. Current weight would be asked at each interview but the applicable lifetime weights were only asked once, so a respondent could have a maximum of seven contributed adult weights. As the interviews were conducted by telephone, weights were reported by the participant and were not measured by a physician or interviewer as was done in the original NHANES I survey, which measured respondent's weight to the nearest 5 g (0·01 lb). While the accuracy of all the self-reported weights cannot be tested, the validity of a single adult measurement can be made by comparing an estimated self-reported weight at the age the respondent was when he or she participated in NHANES I with the actual measured weight obtained at that interview.

The discrepancy analysis was limited to the subset of participants who had at least three self-reported weight measures for ages within 20 to 65 years. This limitation was done because the estimated weight at the time of the NHANES I interview would be based on an assumed linear relationship between weight and age. This estimation procedure would require a minimum of two weight measures and would most suitably represent the relationship between weight and age during the adult, but not elderly, years of an individual's life. Outside this age range weight is unlikely to follow a linear relationship because of growth or ageing effects.

Analysis

All estimations and graphical procedures were conducted in the R programming language (R Development Core Team, Vienna, Austria). Figure 1 displays the general procedure for a random sample of four participants. A least-squares regression line is fit based on the self-reported

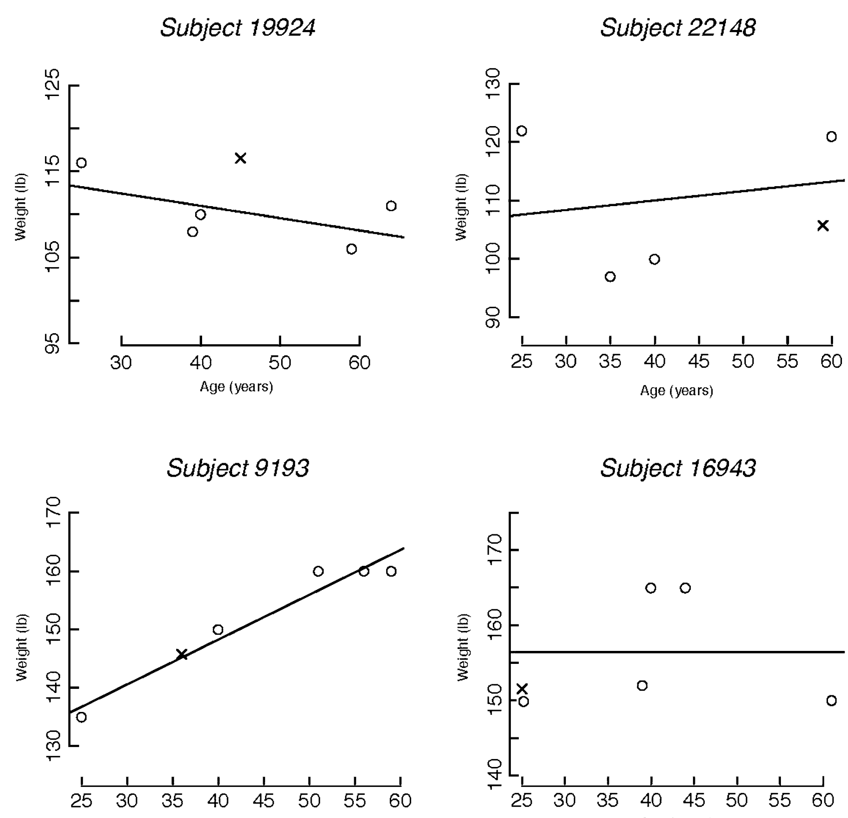

Fig. 1 Plots of self-reported adult weights (○) and actual weight measured at the first National Health and Nutrition Examination Survey (NHANES I) interview (×) for four randomly selected subjects. The solid line is the least-squares fit used to estimate the self-reported weight corresponding to the subject's age at NHANES I. To convert to kilograms, multiply pounds by 0·454

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weights for a given individual. The dependent variable is weight in pounds and the independent variable is the continuous age in years. An estimate is made for the weight at the age the respondent was at the time of the NHANES I interview based on the fitted line. The weight discrepancy is defined as the NHANES I-measured weight minus this estimated weight. Positive values for the weight discrepancy therefore reflect self-report weights that underestimate the true weight. The actual measured weights are indicated by the cross symbols. From this random sample, we see both positive and negative deviations.

Table 1 Characteristics of the NHEFS eligible sample (*n* 6101)

Characteristic	Mean or %	SD
Age at NHANES I (years)	35·5	7·2
BMI at NHANES I (kg/m^2)	25·2	5·3
Time elapsed from NHANES I to follow-up (years)	19·3	2·2
Female (%)	66·8	–
White (%)	85·2	–
Some college education (%)	27·6	–
Weight discrepancy (kg)	1·77	7·03
Weight discrepancy (lb)	3·9	15·5
Correlation of estimated and measured weight	0·96	–

NHEFS, NHANES I Epidemiological Follow-up Study; NHANES I, first National Health and Nutrition Examination Survey.

There were 6101 persons in the NHANES follow-up sample who had sufficient self-reported weight measures to be eligible for inclusion in the analysis. The characteristics of these individuals are given in Table 1. The majority were White, with only 13·5% of African-American and 1·2% of Other race. There were slightly more female respondents. More than two-thirds of the sample had at least a high-school education.

The age of the subjects at the NHANES I original interview was generally more than 35 years. At the time of the original interview, 43·3% of the individuals had a relative weight (BMI) greater than 25 kg/m^2, the conventional threshold for overweight. For most, it had been over 19 years since their NHANES I interview when the follow-up information was obtained.

If any self-report bias was found for the overall sample, it was of interest to determine how this bias varied across demographic groups, with BMI and the duration of recall. A multiple linear regression analysis was performed to investigate these questions. The mean weight discrepancy was modelled as a linear function of demographic category, which were the eighteen unique race, gender and education groups, centred BMI (determined at the NHANES I interview), time elapsed (years) between the NHANES I interview and follow-up and the interaction between the centred BMI and demographic category.

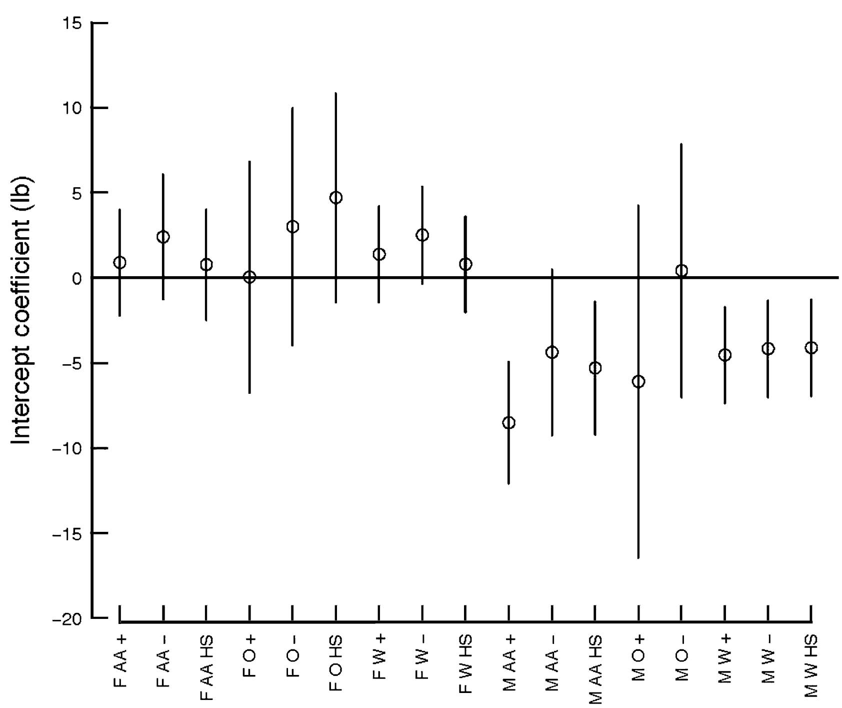

Fig. 2 Intercept coefficient point estimates (○) and their standard errors (±2SE, represented by vertical bars) by demographic group in a multiple linear regression with the weight discrepancy (measured minus estimated) in pounds as the dependent variable and demographic group, centred BMI at the first National Health and Nutrition Examination Survey (NHANES I), time elapsed from NHANES I to follow-up and the interaction of centred BMI and demographic group as independent variables. The centred BMI variable was the respondent's BMI minus 25 kg/m^2. The demographic groups are based on gender (F = female, M = male), race (W = White, AA = African-American, O = Other) and educational attainment (– = less than high school, HS = high school, + = some college). To convert to kilograms, multiply pounds by 0·454

Thus, the resulting model can be considered a varying intercept and slope model with an adjustment for the time of recall, i.e. the elapsed years from NHANES I. The centred BMI is simply the continuous BMI of the respondent at the NHANES I interview minus 25 kg/m^2, the minimal BMI for an overweight status. This centring was done to make the regression intercept and demographic regression coefficients more interpretable as they would then refer to the mean weight discrepancy for a person of the corresponding demographic group with a BMI of 25 kg/m^2 and no recall bias.

When this linear model was fit with the full data, three influential points were found. An observation was considered influential if it had a Cook's distance greater than 0·5. To improve the robustness of the analysis these points were removed, so the final analysis was on 6098 of the original 6101 sample.

Results

Table 1 shows the mean estimated discrepancy between the measured and self-reported weight for the full sample. The correlation was 0·96. The mean is 1·77 kg (3·9 lbs) and the standard error is 0·09 kg (0·2 lb), which corresponds to a mean discrepancy that is significantly greater than zero ($P < 0{\cdot}001$) and biased towards under-reporting weight. Considering the large passage of time for most of the respondents, an average inaccuracy of the order of 1·81 kg (4·0 lb) is small. The small magnitude of the bias and the strength of the correlation between the measured and estimated self-report weight suggest that telephone interviews of lifetime adult weight can give good approximations to actual lifetime adult weight profiles. However, the large standard deviation (7·03 kg (15·5 lb)) suggested that there was likely to be systematic variation in the weight discrepancy between major demographic subgroups. A multiple regression analysis was employed to study whether the weight bias varied by demographic group, measured BMI or recall duration as detailed above. The adjusted R^2 was 0·4, suggesting an overall adequate fit.

Plots of the regression coefficients for the intercept and centred BMI are given by demographic category in Figs 2 and 3. In general, since there were only seventy-six individuals of Other race for the full sample, all of the estimations for the demographic groups of Other race have large standard errors. Estimates for the subgroup of male, high-school graduates of Other race were entirely removed from the presented results as there were only two individuals represented in this group.

The intercept values correspond to the mean weight discrepancy for an overweight individual (BMI of 25 kg/m^2) when the time of the weight measure and self-reported

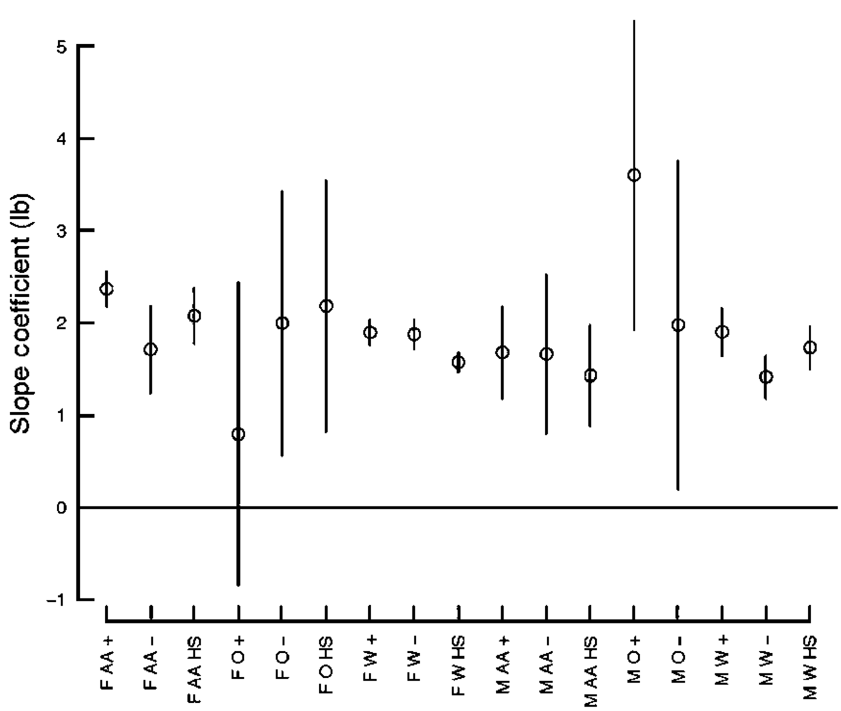

Fig. 3 Slope of centred BMI coefficient point estimates (○) and their standard errors (±2SE, represented by vertical bars) by demographic group in a multiple linear regression with the weight discrepancy (measured minus estimated) in pounds as the dependent variable and demographic group, BMI at the first National Health and Nutrition Examination Survey (NHANES I), time elapsed from NHANES I to follow-up and the interaction of BMI and demographic group as independent variables. The demographic groups are based on gender (F = female, M = male), race (W = White, AA = African-American, O = Other) and educational attainment (− = less than high school, HS = high school, + = some college). To convert to kilograms, multiply pounds by 0·454

value are identical. The open circles give the point estimate and the lines cover the range from minus to plus two standard errors, corresponding to a 95 % confidence interval for the coefficient estimate (Fig. 2). After adjusting for recall and BMI, there is a slight tendency of under-reporting weight among women. By contrast, there is a strong tendency for men to over-report weight, particularly among White males of all education types and African-American males with at least a high-school education. However, the demographic effect in the mean discrepancy is small, within 2·27 kg (5·0 lb), with the exception of African-American males of high education for whom the discrepancy is 3·86 kg (8·5 lb) on average.

The coefficient for the time elapsed was 0·20 (SE 0·07; $P<0·001$). Even after controlling for effects due to demographic group and BMI at the time of NHANES I, a greater time between the current age of the respondent and the age of the respondent for the inquired weight was associated with a positive increase in the weight discrepancy. Still, for even 20 years elapsed the bias due to recall would be only 1·81 kg (4·0 lb).

With regard to the slope for BMI centred at the minimal overweight status of 25 kg/m^2, it was found that all coefficients, save that for the female subgroup of Other race and highest education, were significantly greater than zero (Fig. 3). This indicates that, regardless of the demographic group, increasing relative weight is associated with underestimating self-reported weight. There is no evidence that the magnitude of the slope coefficient varied by demographic group. For all groups, there is an average increase in underestimating weight of approximately 0·9 kg (2 lb) for every increase of one unit (1 kg/m^2) in BMI.

The strong relationship between BMI and reported bias suggests that what at first seemed to be a small bias in reported weight might actually translate into notable differences in the estimated prevalence of overweight and obesity. The prevalence rates of individuals with measured BMI greater than 25, 30 and 35 kg/m^2 at the time of the NHANES I interview were 43·4, 15·0 and 4·9 %, respectively. For the estimated BMI using the same measured height the rates were 38·0, 9·6 and 2·5 %. Despite the high correlation between the self-reported and measured weight overall, the strong positive association of BMI to the discrepancy in measured and reported weight results in marked differences in prevalence estimates.

We also investigated how weight fluctuation influences self-report bias. The standard deviation across the self-reported measures provided by each participant was used as the measure of weight variability. When this covariate was included in the regression model it was not statistically significant ($P=0·16$). Weight fluctuation was not associated with bias using an estimation approach based on a self-reported weight profile.

Conclusions

It was found that the accuracy of self-reported weight is most influenced by current BMI and gender. In particular, males tend to overestimate by 2·27 kg (5·0 lb) with moderate evidence that females tend to under-report weight by 0·82 kg (1·8 lb) after controlling for relative weight status. These gender differences are small considering that the typical discrepancy increases by 0·91 kg (2·0 lb) with each increase in BMI of 1 kg/m^2. Although recall did contribute to reporting bias, the results suggest that even for 20–30 years elapsed the bias is unlikely to exceed 1·81 kg (4·0 lb) and 2·72 kg (6·0 lb), respectively.

The present evidence indicates that there is bias in lifetime self-reported adult weight but with small effects due to recall and demographic group. While these finding suggest that race and education were not important factors in the self-report accuracies, the possibility that important ethnic differences exist cannot be excluded as the NHANES I sample was predominantly White. With this limitation in mind, the current analysis found the most critical factor in the accuracy of self-reported weight to be the relative weight of the respondent, with increasing underestimation among the heaviest individuals. Conclusions of previous validity studies of current self-reported weight validity should be questioned if they failed to account for the relative weight status of respondents, particularly since the distribution of BMI will vary across major demographic groups (gender, race, region, etc.). When such an association is present, even small inaccuracies in reported weight could translate into large differences in obesity prevalence estimates. This was shown to be true for the present population, where the self-reported rate of obesity was 64 % that determined by measured BMI.

The current article does not address bias in self-reported height. The focus is on an alternative strategy to eliciting adult weight by relying on a series of lifetime weights as opposed to current weight. If previous evidence of self-report bias in weight arises from sensitivity to a currently undesirable weight, then this retrospective weight profiling would be expected to reduce bias. The small bias found in the investigation suggests that this elicitation strategy could offer an improvement on current weight self-report. This was not tested directly in the present study, so warrants further investigation. A similar approach would not be feasible for adult height. Relative weight measures using the estimated adult weight presented in the current paper would still suffer from whatever additional bias might be introduced by misreported height.

Valuable and accurate weight information can be obtained from self-report interviews but will require caution with groups of overweight or obese individuals. While this is somewhat reassuring, in that only a single factor needs to be controlled to obtain more accurate self-reported adult weight, the factor is the very one that would be the focus of a health survey like NHEFS, i.e. weight status.

Fortunately, the present investigation suggests a strategy to improve the validity of lifetime weight for future health surveys concerned with adult weight profiles or an improved estimate for adult weight and not current weight *per se*. A small sample of overweight and obese individuals can be directly measured and serve as the basis for estimating the necessary adjustment for misreporting weight among individuals with a history of relative weight greater than 25 kg/m^2. Using the NHEFS to test this approach, a sample of only sixty-four men and women (thirty-two each) from each BMI group between 25 and 40 kg/m^2 was selected. From the data for these respondents, a linear regression was used to estimate what adjustment to self-reported weight was needed for each increase in BMI from 25 kg/m^2. By adding the estimated discrepancy for individuals with BMI greater than 25 kg/m^2, treating those with BMI above 40 kg/m^2 as having a BMI of 40 kg/m^2, the mean weight discrepancy on a re-estimate with the full sample was −0·16 kg (−0·35 lb) compared with 1·77 kg (3·9 lb) without any adjustment. This suggests that by focusing only on relative weight at the time of self-report, using a small sample of measured weights among overweight and obese individuals, an estimation procedure could greatly improve the overall validity of the anthropometric weight data without great additional cost in conducting the investigation.

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