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Reliability of self-reported height and weight measurement in the evaluation of adult overweight and obesity

Samira Bahrami Tabar [1] Shahram Zare [1]
Department of Community Medicine [1], Hormozgan University of Medical Sciences, Bandar Abbas, Iran.

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Original Article

Abstract

Introduction: The validity of Body Mass Index (BMI) based on self-reported height and weight is of critical importance in the proper assessment of studies that rely on questionnaire-derived data. In this study, we evaluate the accuracy of adolescent overweight and obesity classification bpased on self-reported height and weight factors and propose a regression model for predicting the true BMI.

Methods: This cross-sectional study has been conducted on 1546 (+18 years og age) living in the south of Iran. The participants were chosen using a multistage sampling scheme. We compare the prevalence of overweight and obesity as well as the mean and standard deviation (SD) of BMI based on self reported and true height and weight. A multiple regression analysis was carried out to build a regression model to predict the true BMI based on sex, age group, and self-reported BMI.

Results: The overall mean±SD of BMI for self reported and real data were 25.2±1.9 and 26.3±2.1, respectively. Estimated prevalence of overweight and obesity were 39.3% and 8.7% based on self reported data, and 60.8% and 15.7% based on the true BMI. On average the true BMI was 1.1 kg/m^2 and 1.3 kg/m^2 higher for men and women, respectively. Consistently over all age groups and weight classes, BMI values computed using exact information were larger than BMI values computed using self-reported data. This finding was more evident for female and obese participants. Regression modeling revealed that sex, age group, and self reported BMI are the most reliable factors for predicting the true BMI.

Conclusion: In etiological studies and studies that analyze the relation between various diseases and obesity and overweight, it is preferable to use true values of height and weight. However, in the absence of true data, the suggested regression model can be used to predict the true BMI with a narrow 95% confidence interval and a desirable 95% prediction interval.

Correspondence:
Shahram Zare, PhD.
Department of Community Medicin, Hormozgan University of Medical Sciences.
Bandar Abbas, Iran
Tel:+98 9171613924
Email:
Shzare@hums.ac.ir

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Introduction:

The World Health Organization (WHO) has introduced obesity as one of the most important public health issues that threatens people all over the world (1). As a medical disorder, obesity not only affects physical and mental health, but also results

in a collection of associated diseases such as hypertension, type II diabetes, cardiovascular diseases and even various types of cancer (2-5).

Moreover the consequences of such diseases impose a heavy economic burden on the society. A recent report issued by the European office of WHO indicated that the increased rate of overweight and obesity is a cause of about 80%, 35% and 55% of type II diabetes, cardiovascular diseases and hypertension prevalence, respectively; meanwhile, overweight results in over one million deaths and 12 million living with disease every year (6).

National studies conducted in Iran also reported age-adjusted overweight in women and men to be as large as 57% and 42.8%, respectively; out of which 25.2% of women and 11.1% of men suffered from obesity (7-9). The results of two separated studies conducted in 2002 and 2006 in southern part of Iran on 1500 and 1329 adults (+18 years of age) showed an increasing trend in the overweight and obesity prevalence of men and women; from 34.1% to 45.3% and from 31.8% to 37.1% in the overweight prevalence of men and women, respectively, and from 9.1% to 10.2%, and from 14.7% to 21.1%, in the obesity prevalence of men and women, respectively (10).

The increasing trend of overweight and obesity prevalence in south of Iran, alike other parts of Iran (8,9) and other parts of the world (11), can be due to rapid socio-economic transition accompanied by cultural changes, reduction of communicable diseases, increase in life expectancy and ever-changing lifestyle. Therefore, monitoring overweight and obesity trends changes is of significant importance from both a medical and economic standpoint. As the calculation of BMI is simple, inexpensive, quick and recoverable, it is used broadly by different studies which are conducted based on population to diagnose underweight, normal weight, overweight and obesity (7). BMI is also used to estimate the risk of mortality (2).

Currently, many epidemiologic and national studies rely on self-reported weight and height measurements to compute and analyze BMI. Since people tend to misreport their height (to be more than what it is) and weight (to be less than what it is), the accuracy of BMI in these studies is, at best, questionable.

Several studies have shown that the accuracy of self-reporting varies among different societies and age groups and can suffer from systematic errors (12-14). Obese people usually report their weight as being less than what it really is and women misreport their real weight more often than men. On the other hand, underweight people may falsely increase their BMI by reporting their weight as being more than what it really is. In addition, as people get older, misreporting their weight and height measurements can result in underestimating their true BMI.

To the best of the authors' knowledge, a comprehensive investigation into the reliability of self-reported weight and height measurements in the calculation of BMI in Iran, and especially in the south of Iran, has not yet been conducted.

The current study not only analyzes the overweight and obesity prevalence in terms of BMI using: i) self-reported, and ii) accurate measured height and weight, but it also offers a simple and reliable model to estimate the exact BMI based on the available data, which is largely based on self-reported information.

Methods:

This population-based cross-sectional study was carried out in the rural and urban areas of Hormozgan province, the largest southern province of Iran, in 2013. A stratifies multi-stage sampling scheme was used to form a sample representing the whole population of the area. Initially, the province was divided into four zones (strata), and regarding the population of each zone a proper number of clusters was allocated to each stratum. Then, the Iranian national zip code database was used to determine the postal address of starting points in each cluster. A counterclockwise movement from this starting point was used to select a representative sample of residential units and in each residential unit one person was randomly selected from the group of people who were over 18 years of age.

In order to maximize the participation of people, sampling process was conducted after working hours. In cases in which people failed to cooperate with the authors, the adjacent household would be

selected for sampling. Since determining the actual weight of certain groups of people is difficult, pregnant women, people on special diets, the homeless, dormitory residents, and the armed forces were excluded form this study. Overall, 1546 individuals, containing 714 (46.2%) men and 832 (53.8%) women, participated in the study.

After selecting samples, a pre-designed questionnaire was used to record certain information such as age, gender, education level, height and weight. This was followed by an accurate measurement of the person's height, and weight; the standing height in barefoot mode was measured using a metal stadiometer to the nearest 0.5 cm, and the person's weight was measured using a standard scale to the nearest 0.1 kg. The measurement process was conducted by previously trained health workers.

According to WHO standards, body mass index is measured as a person's weight in kilograms divided by the square of height in meters; hence BMI $<$ 18.5 is considered underweight, BMI = 18.5-24.9 is in normal range, BMI = 25 -29.9 is overweight and BMI $\geq$ 30 is obese (15).

The Medical Ethics Committee at Hormozgan University of Medical Sciences approved the study protocol and all subjects were asked for a written informed consent before participating in the study.

The collected data were analyzed using Minitab-22 statistical software. Initially, BMI was calculated using the true and self-reported height and weight values. Overweight and obesity prevalence was determined for various age and gender group.

Multivariate regression was used to analyze the relationship between the true BMI and certain variables such as self-reporting BMI, age and gender and $P < 0.05$ was considered significant.

Results:

The data of a total number of 1483 individuals, 676 (45.6%) men and 807 (56.4%) women, were analyzed. Sixty three people were excluded because their information was incomplete. The overall prevalence of overweight and obesity were 39.3% and 8.7% based on self-reporting data; whereas it was determined to be 60.8% and 15.7% based on true measurements. These rates varied for men and women, with obesity prevalence rates based on true measurements being higher for women than for men; see Table 1.

The highest difference between self-reported and true BMI was found in under 30-year old women. Further data analysis indicated that 69.2% of men and 35.6% of women, who have been diagnosed as obese based on true measurements, had also been categorized in this group based on self-reported information. The average BMI using self-reported data was 25.2±1.9; whereas it was calculated to be 26.3±2.1 using true information.

Table 2 includes the estimated mean and standard deviation of self- reported and true BMI based on sex, age, and actual weight group. The average amounts of BMI based on self-reporting and true information for women were 25.4±2.1 and 26.7±2.2, respectively; whereas they were 24.8±1.7 and 25.9±1.8 for men. In other words, the difference between the average amounts of BMI calculated based on self-reporting and real information was 1.1; the differences for women and men was 1.3 and 1.1, respectively. For all age groups and weight classes, the BMI calculated using true height/weight information was more than the BMI estimated using self-reporting data and this issue was more evident in women and obese individuals.

In this study, the multivariate regression model was used to evaluate and predict the relationship between the true BMI measured using actual height/weight measurements and other variables, such as age, gender, education level and the self-reported BMI; Table 3. When adjusting for age, results show that on average women under-report 0.24 BMI (kg/m^2) more than men ($P < 0.001$). The results also show that the age is a significant factor in misreporting BMI. For instance, individuals in the age group of $>$60 years old, misreported about 1.24 BMI (kg/m^2) compared with the reference age group, which was 18-30 years old ($P < 0.001$).

Table 1. Percentage of individuals with overweight and obesity based on self-reported and real values by sex and age group

	Female				Male			
	Overweight		Obesity		Overweight		Obesity	
Age Group	SBMI	RBMI	SBMI	RBMI	SBMI	RBMI	SBMI	RBMI
18-30	28.0	60.6	8.7	19.6	34.3	71.9	9.2	14.8
31-40	42.7	55.6	4.1	17.3	58.8	72.8	7.9	13.7
41-50	47.6	67.2	6.1	17.6	30.6	67.4	10.2	11.8
51-60	42.1	61.2	8.5	15.6	33.0	65.9	8.3	11.2
>60	39.0	35.8	7.9	15.3	31.9	46.6	8.2	10.1
Total	40.1	60.1	6.8	17.8	38.3	62.6	8.9	13.4

SBMI= Self-Reported Body Mass Index , RBMI= Real Body Mass Index

Table 2. mean (Sd) of self-reported and real BMI based on sex, age group and real weight class

	Female			Male		
	SBMI	RBMI	RBMI-SBMI	SBMI	RBMI	RBMI-SBMI
Age group	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)
18-30	25.0 (2.3)	26.9 (2.5)	1.9 (0.4)	24.8 (1.6)	26.1 (1.7)	1.3 (0.3)
31-40	25.3 (1.7)	26.9 (1.7)	1.6 (0.3)	25.1 (1.4)	26.5 (1.5)	1.4 (0.4)
41-50	25.5 (2.2)	27.0 (2.3)	1.5 (0.4)	25.0 (2.3)	26.1 (2.4)	1.1 (0.4)
51-60	25.7 (2.0)	26.5 (2.1)	0.8 (0.1)	24.8 (1.2)	25.6 (1.3)	0.8 (0.3)
>60	25.6 (2.2)	26.0 (2.3)	0.4 (0.4)	24.5 (1.7)	25.0 (1.7)	0.5 (0.2)
Total	25.4 (2.1)	26.7 (2.2)	1.3 (0.7)	24.9 (1.7)	25.9 (1.8)	1.1 (0.5)
Real Weight group						
Normal	23.3 (1.0)	24.1 (0.8)	0.8 (0.6)	23.1 (1.4)	23.8 (1.4)	0.7 (0.4)
Overweight	25.7 (1.5)	27.1 (1.4)	1.4 (0.6)	25.4 (1.1)	26.5 (1.1)	1.1 (0.4)
Obese	29.9 (1.5)	31.6 (1.4)	1.7 (0.8)	30.1 (0.7)	31.1 (0.8)	1.0 (0.3)

SBMI= Self-Reported Body Mass Index , RBMI= Real Body Mass Index, Sd= Standard Deviation

Table 3. Regression model of the relation between real BMI and sex, age group and BMI based on self reported height and weight

Variable		β	SE	t	P-value	95% CI for β
Constant		0.928	0.123	7.571	<0.001	(0.688 – 1.169)
Self-reported BMI		1.024	0.005	209.039	<0.001	(1.014 – 1.034)
Sex	Male (reference)					
	Female	0.239	0.019	12.492	<0.001	(0.202 – 0.277)
Age group	18-30 (reference)					
	31-40	-0.145	0.029	-4.975	<0.001	(-0.202 – -0.088)
	41-50	-0.334	0.028	-11.691	<0.001	(-0.390 – -0.278)
	51-60	-0.862	0.031	-28.114	<0.001	(-0.922 – -0.802)
	>60	-1.243	0.029	-42.216	<0.001	(-1.301 – -1.185)

Table 4. Predicted values of BMI based on the regression model for 10 randomly selected cases from different sex and age group

Case No.	Sex	Age group	Self-reported BMI	Predicted BMI	95% CI for predicted BMI	95% PI for predicted BMI	Mean (Sd) of the residuals for similar cases
1	F	18-30	24.4	26.15	(26.11 – 26.20)	(25.44 – 26.86)	0.18 (0.29)
2	M	18-30	27.3	28.88	(28.83 – 28.93)	(28.17 – 29.60)	-0.19 (0.48)
3	F	31-40	23.9	25.50	(25.45 – 25.54)	(24.78 – 26.21)	0.06 (0.23)
4	M	31-40	26.4	27.82	(27.77 – 27.86)	(27.10 – 28.53)	0.01 (0.43)
5	F	41-50	27.8	29.30	(29.25 – 29.35)	(28.59 – 30.01)	0.17 (0.19)
6	M	41-50	25.1	26.30	(26.25 – 26.34)	(25.58 – 27.01)	-0.18 (0.30)
7	F	51-60	25.4	26.31	(26.27 – 26.36)	(25.60 – 27.03)	-0.08 (0.01)
8	M	51-60	24.5	25.15	(25.10 – 25.20)	(24.44 – 25.87)	0.20 (0.33)
9	F	>60	28.3	28.90	(28.85 – 28.96)	(28.19 – 29.62)	-0.25 (0.24)
10	M	>60	22.5	22.72	(22.67 – 22.77)	(22.01 – 23.44)	0.27 (0.13)

CI= Confidence Interval PI = Prediction Interval Sd= Standard Deviation

According to the results, education level did not have a significant effect on BMI reporting. Meanwhile, the coefficient of determination for this model measured to be R^2=0.94, and thus provides an efficient prediction of true BMI based on four available variables; sex, age, self-reported height, and weight.

To assess the reliability of this model in predicting the BMI, five men and five women were randomly selected from various age groups and then their BMI was estimated using a regression model based on age, gender, reported amount of height and weight (Table 4).

The results show that maximum width of 95% confidence intervals is less than 0.1 for the estimated amount in all age groups. Both 95% confidence interval and 95% prediction intervals were measured for the selected samples. Moreover, mean value and standard deviation of residuals, i.e. the difference between the true BMI and estimated values, were measured for the selected samples with the same sex, age group, and self-reported BMI within a range of $\pm$0.5 (Table 4). A very low residual standard deviation indicates high reliability of the model and confirms the appropriateness of the regression model.

Conclusion:

To the best of the authors' knowledge, no previous comprehensive study has been conducted in Iran to examine the effect of self-reported height/weight data in the estimation of BMI. The results of this study indicate that the self-reported weight and height information, especially those which are population based, will result in misrepresentation of BMI. This study demonstrated that underestimation of BMI is the result of overstating one's height by short-heighted people and understating one's weight by obese people. This result is in agreement with the findings of John et al (16), Akhtar Danesh et al (17), and Sherry et al (18).

In our study, age was significantly associated with a probability of inconsistency between true BMI and BMI based on self reported data. In both sex groups, younger individuals were more likely to overestimate their height and underestimate their weight. In other words, an indirect correlation was observed between age and over-estimating height, and a direct relationship was found between age and underestimating weight, subsequently resulting in the misrepresentation of BMI. This contradicts the findings of Kuczmarski et al (13), Villanueva (19) and Hill et al (20), which found a direct relationship between the tendency to understate BMI and age. In our study, various age groups showed different behaviors in reporting their height and weight for BMI calculation which can be due to cultural reasons. This is also the case in other societies (17,20).

In our study, the underestimation of BMI for men and women was approximately 1.1 and 1.3, respectively. This is larger than what was measured by Neidzwiedzka (21) in Poland, in which the average underestimation of BMI for women and

men was reported as being 0.6 and 0.7 units, respectively.

In general, the majority of studies have shown that overweight or obese people wish to be categorized in an incorrect category (17). Monteagudo and colleagues (22) in their study which considered elderly Dutch adults declare that only 4.4% of obese men and 12.3% of obese women have a correct perception of their weight status. Akhtar-Danesh et al (17) in their study in Canadian adults show that 25% of obese men and 44% of obese women were misclassified when self-reported height and weight was used for BMI calculation. In our study, 31% of obese men and 64% of obese women, whose BMI was measured by their self-reported weight and height, were categorized incorrectly. In the same vein, 47% of overweight men and 49% of overweight women were incorrectly categorized in the normal BMI range group. Incorrect categorization of people in terms of BMI can result in underestimation of the relative risk of obesity-related diseases. This indicates the necessity for additional caution when drawing conclusions from self-reported height and weight information.

In this study, the prevalence of obesity, based on self-reported and true measurements, was measured 8.7% and 15.7%, respectively. Similar results were reported in other studies (13,14). This large discrepancy is non-negligible when it comes to medical and public health considerations.

Overweight and obesity have considerable effect on a society's health and underestimating them can influence medical and health related planning and polices. In othe words, this phenomenon can overshadow the results of studies about risk factors of obesity and overweight, which can subsequently cause the underestimation of obesity-related diseases and their influence on the society.

Another important objective of this study was to use a multivariate linear regression method to design a simple model that could estimate the real amount of BMI with high reliability using available variables. This model with the coefficient of determination of 0.96, predicts the real value of BMI using four simple accessible variables including gender, age, self reported weight and height. This model does not depend on any other variables.

In general, it is desirable to use true values of weight and height for the evaluation of both obesity and overweight in etiological studies and studies that analyze the relation between various diseases with obesity and overweight factors. However, if such information is unavailable, our model can be used to predict the true value of BMI with a narrow 95% confidence interval and a desirable 95% prediction interval.

To the best of our knowledge, this is the first statistical model to predict the true value of BMI in Iranian adults. We note that the reliability of this model should be assessed through proper intervals using available databases.

Conflict of interest:

The authors declare no potential conflict of interests.

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