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A Study of Self-Reported and Actual BMI

by

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The body mass index (BMI) has been used as a measure for adult under weight, overweight, and obesity. In many surveys, such as the Continuing Survey of Food Intakes by Individuals (CSFII), the National Longitudinal Survey of Youth, the Behavioral Risk Factor Surveillance System (BRFSS, CDC 2007a) surveys, among others, information of self-reported body weight and standing height was collected and used to calculate the body mass index (BMI) and the self-reported weight and height were used in empirical studies of obesity (USDA 2002; Kuchler and Lin 2002; Lin et al. 2004; Boumtje et al. 2005; Baum and Ruhm, 2007). Many studies have compared the self-reported and measured weights and heights. The results of these studies show that self-reported weight and height were generally highly correlated with corresponding measured dimensions; however, the errors in self-reported weight and height were related to respondents' weight status, demographics (Rowland 1990; Spencer et al. 2001; Wang et al. 2002; Himes et al. 2004; Gillum and Sempos 2005; and Taylor et al. 2006; Gorber, et al. 2007), and data collection methods (Ezzati et al. 2006). However, the influence of the errors in self-reported weight and height on the results of obesity studies has not been examined. In the National Health and Nutrition Examination Survey 2003-04 (NHANES, National Center for Health Statistics), both actual height/weight and self-reported height/weight were reported, thus provides an opportunity to examine if the measured and self-reported height and weight would give different results on obesity research.

The purpose of this study is to examine the differences between self-reported and measured BMIs, and if there are concerns when self-reported BMIs, instead of actual

BMIs, were used in studying the factors that influence BMI. We will first describe the data to be used in this study, followed by a comparison of the self-reported and actual BMIs, an analysis of the factors that influence the discrepancies between self-reported and actual BMI, then examines what happens to the parameter estimates from an analysis of the factors that influence a person's weight status.

Data

In NHANES 2003-04, only the participants of ages 16 years and older were asked the current self-reported height and weight questions. Because of food intake information is needed to examine the factors that influence a person's weight status in the second part of the analysis; only the participants of ages 16 years or older and who had both days of food intake recorded were use in this study. Out of the 10,122 NHANES 2003-04 respondents, 4,907 of them satisfied these two conditions and the information collected on these respondents was used in the following analyses.

Table 1 shows the sample statistics of self-reported and measured height/weight and BMI. Note that the average self-reported weight is lighter than the actual weight, the self-reported height is greater than the actual height, and the BMI derived from self-reported weight and height is smaller than the actual BMI. Although the average differences between the self-reported and actual height, weight, BMI, respectively; are small; the ranges of the differences are wide. For example, the mean difference between self-reported height and actual height is 1.188 cm, but the range of the differences is 59.90cm, or [-34.18, 25.72]. Similar wide ranges for the differences between self-reported and actual weight (83.58kg) and BMI (35.95) exist. Sample statistics at the bottom of Table 1 also show that 2.3% of the participants were underweight (BMI <

18.5), 36.4% had healthy weight (18.5 ≤ BMI < 25), 32.6% were overweight (25 ≤ BMI < 30), and 31.1% were obese (BMI ≥ 30) (CDC-2007b). Table 2 shows the self-reported and actual weight/height and BMI by participant's weight status. The statistics shown in Table 2 indicate that heavier participants (overweight and obese) tended to report they were taller and lighter than they actually were and underweight respondents tended to overstate their body weight. As a result, 46.5% of the underweight respondents were classified as healthy weight, 18.2% of the overweight respondents were classified as healthy weight and 17.1% of the obese respondents were classified as overweight when self-reported BMIs were used.

Self-Reported Weight/Height and Demographics

Are the differences between self-reported and actual height/weight/BMI just random or they can be explained by participant's weight status (i.e., underweight, or overweight, or obese) and demographics? A recent USDA (2002) study of adults' weight status (BMI) and their perceptions of their own weight status show that mistakes have a systematic component and are associated with demographics, socioeconomic status, and knowledge and attitudes toward diet and health. In the following analysis, we assume that the differences in the self-reported and actual height, weight, and BMI can be explained by participant's self-reported weight status, measured weight, and several selected demographic variables such as age, education, household income, marital status, gender, and poverty level. The dependent variables are the difference between self-reported and actual height (or weight, or BMI). The explanatory variables and their definitions are listed at the bottom half of Table 2.

Three multivariate regression models were fitted with the differences between self-reported and measured height, weight, and BMI; respectively. Regression results are presented in Table 3.

Regression results for the height equation show that participants who considered themselves underweight over reported their height by 0.29cm, female participants under reported their height by an average of 0.39cm, participants under 36 years old under reported their height and those who were older than 36 years over reported their height, and compare to other participants, married and divorced participants under reported their height by 0.08cm and 0.12cm, respectively. Compared to other race, white, black, and Hispanic participants under reported their height. Obese and overweight respondents over reported their height by 0.96cm and 0.57cm, respectively.

Results for the weight equation show that participants who considered themselves overweight over reported their weight by 1.10kgs, female participants under reported her weight by 2.08kgs, younger participants tended to over report their weight, and as years of education increase people tended to under report their weight. Compared to other race, white, black, and Hispanic participants over reported their weight. The participants who were overweight and obese understated their weight by 2.27kgs and 4.48kgs, respectively; and the participants who were underweight overstated their weight by 2.36kgs.

As a result of errors in self-reported height and weight, the BMIs derived from the self-reported height and weight are also inaccurate. Regression results for the BMI equation show that participants who considered themselves overweight overstated their BMI, the overweight and obese respondents understated their BMIs by 1.01 and 2.04,

respectively; while the self-reported BMIs for those participants who were underweight are higher than their actual BMI by 0.88. Due to inaccurate self-reported weight and height, the self-reported BMI for female participants and participants with more education are lower than the actual BMI by 0.65 and 0.04, respectively. The self-reported BMIs for married participants are lower than their actual BMIs. Compared to other race, white, black, and Hispanic participants over reported their BMI. Note that in this analysis, income had no influence on the differences between self-reported and actual weight/height/BMI.

Self-Reported and Actual BMI in an Obesity Study

BMIs have been used to determine if a person is underweight, overweight, obese, or has healthy weight. Several recent studies examined the factors that influence a person's weight status. How much a person weights is likely due to a combination of factors. These factors include dietary habits, genetic makeup, socio-economic status, family lifestyle, and quality of diet. In this study, we use the approach by Lin et al. (2004). Table 4 lists the variables included in the analysis of BMI and their definitions.

Socio-economic and demographic variables include household income, race, Hispanic origin, age, gender, education, and marital status. Note that NHANES 2003-04 did not report household size; therefore, we cannot use per capita household income in the analysis. The dietary variables include the times the participant ate breakfast during the two-day recalls, the percent of total calories came from fats and oils, the percent of beverages consumed that was soft drinks, the percent of milk consumed that was low-fat milk, the percent of total calories that came from away-from-home food consumption, and if the participant took vitamin supplements. In addition to dietary and socio-

demographic variables, we also included a dummy variable for smoking and a variable for the amount of exercises the participant did during the past 30 days.

Previous studies suggest that physical activities are found to associate with significant reduction of excessive adiposity. The NHANES 2003-2004 collected leisure-time activity information of the participants, including the type of activities, number of times and average duration in minutes of the activity in the past 30 days. Metabolic equivalent of task levels (MET – in minute) is a physiological concept expressing the energy cost of physical activities and is a measure of intensity and rate (Ainsworth et al. 2000). The MET level for an activity is defined as the ratio of the metabolic rate associated with that activity divided by the resting metabolic rate. For example, walking, jogging, and running are assigned MET scores of 3.5-5, 6-7 and 7-10, respectively. MET levels are available in NHANES 2003-04 for all leisure activities reported. To measure the exercise level, we first converted leisure activities into metabolic equivalent (MET) levels using the following formula

A_i = (number of times in 30 days)*(average duration in minutes)*(MET $level_i$), where A_i represents the MET level of activity *i* for an individual and the sum of A_i over all leisure activities for an individual is the measure of exercise used in this study. Table 5 presents parameter estimates for the two regressions.

Results show that demographic, dietary, and lifestyle factors are related to BMI, which is consistent with previous study results. The regression results for actual BMI show that the BMI for female was not different from the BMI for male, as people grow old, BMI increases but peaked at age 54, then decreases slowly. Household income level did not influence the participant's BMI and married and divorced participants had higher

BMIs than single participants. Black and white participants had higher BMIs than other races. Hispanics had higher BMI than non-Hispanic. Food stamp participants had higher BMIs than non-participants. Many dietary and meal patterns were significant at $\alpha = 0.05$ level. The participants who ate breakfast had lower BMIs than those who did not eat breakfast. The percent of calories consumed from fats and oils positively influenced BMI. The share of soft drinks of total beverages was positively linked to higher BMIs. The participants who took vitamin supplements had lower BMIs. Results also show that BMIs were linked to participants' lifestyle choices. Smokers tended to be thinner than non-smokers. Participants who exercised weighed less than those who exercised less. These results are consistent with the ones found in Lin, Huang, and French (2004).

Regression results for self-reported BMIs are similar to the results for actual BMIs except the estimates for the female variable have opposite signs in the two regressions and that the magnitudes of the estimates are different; however, the actual BMI estimate is not significant. The results from the self-reported BMI equation are similar to those found in the actual BMI equation; however, there are less number of statistically significant parameters in the self-reported BMI equation than in the actual BMI equation and sometimes, the signs are different from those in the actual BMI equation. The standard errors of the coefficients in the self-reported BMI equation are, in general, several times larger than their respective standard errors in the actual BMI equation. Additionally, the goodness-of-fit measure, R^2, is much lower for the self-reported BMI equation (0.0061) than the R^2 for the actual BMI equation (0.0897). The following analysis was carried out to examine if the two sets of estimates are different

(3) $BMI_i^a = \alpha_1 + \beta_1' x_i + \varepsilon_{1i}$

$$BMI_i^s = \alpha_2 + \beta_2'x_i + \varepsilon_{2i}$$

where BMI_i^a and BMI_i^s are the actual BMI and self-reported BMI for respondent *i* respectively; x_i is a vector of explanatory variables, and ε_{1i}, ε_{2i} are disturbance terms. The difference of these two equations can be written as

(4) $$BMI_i^s - BMI_i^a = (\alpha_1 - \alpha_2) + (\beta_1 - \beta_2)'x_i + (\varepsilon_{1i} - \varepsilon_{2i}).$$

One can test if $(\alpha_1 - \alpha_2)$ and $(\beta_1 - \beta_2)$s are different from zero.[1] If they are indeed zeros, then the two sets of estimates are not different, otherwise, they are different. Results are presented in the last two columns of Table 5.

The results of equations (3) show that the magnitudes of the two sets of parameters are different; however, their differences, equation (4), as shown in the last two columns, are not statistically different from zero except for the estimates for the female and age variables. The insignificant differences in parameter estimates found in the self-reported BMI and actual BMI equations could be the result of large standard errors of coefficient estimates found in the self-reported BMI equation.

Concluding Remarks

The results of the analysis indicate that overweight and obese people tend to under-report their weight and over-report their height (Table 2). As a result, the average BMIs calculated from the self-reported weight/height are lower than their actual BMIs. A regression analysis of the relationship between BMI and a selected set of explanatory variables demonstrates that one may obtain different results when self-reported BMIs are used as the dependent variable in the analysis of the factors that influence a person's

[1] Note that respondents were interviewed and asked to provide self-reported body weights and heights before taking the actual body weight and height information. Therefore, the self-reported and actual BMI can be considered independent events.

weight status. In general, the coefficient estimates obtained from self-reported BMI have similar signs as those obtained using actual BMI; however, the magnitudes of the estimates obtained from self-reported BMI estimates may differ and their corresponding standard errors may be large. Therefore, one should be cautious when using self-reported BMI in obesity research.

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Table 1. Self-report and actual weight, height, and BMI by weight status

	Underweight		Healthy weight		Overweight		Obese	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Current self-reported height (cm)	168.91	10.36	169.01	10.54	169.57	10.52	168.78	10.73
Standing Height (cm)	168.15	9.53	168.24	10.06	168.24	10.17	167.38	10.20
Current self-reported weight (kg)	52.52	7.19	63.89	9.80	77.19	11.26	97.07	18.65
Weight (kg)	49.81	6.24	63.18	9.12	77.76	10.31	99.72	18.44
Self-reported BMI	18.34	1.21	22.29	2.06	26.75	2.18	33.99	5.33
Body Mass Index (kg/m**2)	17.55	0.75	22.24	1.73	27.37	1.41	35.50	5.23
Self-reported minus Actual (Difference)								
Height	0.76	3.03	0.90	0.77	1.33	3.23	1.40	3.35
Weight	2.71	3.15	0.72	0.70	-0.57	4.01	-2.65	6.41
BMI	0.79	1.04	0.01	0.05	-0.62	1.76	-1.51	2.63

	Classified by Actual BMI as							
Classified by Self-Reported BMI	Underweight		Healthy weight		Overweight		Obese	
	# Persons	% of Actual	# Persons	% of Actual	# Persons	% of Actual	# Persons	% of Actual
Underweight	61	53.5%	43	2.6%	2	0.1%	0	0.0%
Healthy weight	53	46.5%	1484	88.9%	291	18.2%	24	1.6%
Overweight	0	0.0%	140	8.4%	1209	75.6%	261	17.1%
Obese	0	0.0%	3	0.2%	97	6.1%	1239	81.3%
Sample size	114		1,670		1,599		1,524	

Table 2. Sample statistics – equation (1)

Variable	Mean	Std Dev	Minimum	Maximum
Actual				
Weight (kg)	78.971	20.204	33.700	209.100
Standing Height (cm)	167.968	10.131	133.700	204.400
Body mass index (kg/m**2)	27.922	6.449	14.700	64.970
Current self-reported				
Weight (kg)	78.264	19.471	36.287	181.437
Standing Height (cm)	169.115	10.588	121.920	210.820
BMI	27.287	6.025	14.998	64.747
Self-reported minus Actual (Difference)				
Weight	-0.707	4.901	-41.762	41.817
Height	1.147	3.292	-34.180	25.720
BMI	-0.634	2.089	-15.945	20.003
Age (years)	44.135	21.672	16	85
Education (years)	12.223	3.495	8	16
Household Income ($000)	43.518	27.741	0	85
Proportion				
Married	0.449	0.497		
Divorced	0.181	0.385		
Female	0.518	0.500		
Poverty (<1)	0.245	0.430		
Underweight (BMI < 18.5)	0.023	0.151		
Normal (18.5 ≥ BMI < 25)	0.364	0.481		
Overweight (25 ≥ BMI < 30)	0.326	0.469		
Obese (BMI ≥ 30)	0.311	0.463		
Self-image: over weight	0.502	0.500		
Self-image: under weight	0.062	0.242		
Sample size	4,907			

Table 3. Regression results

Variable	Height		Weight		BMI	
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
			16+ Years			
Intercept	1.9603*	0.4195	-1.0626*	0.5919	-0.8733*	0.2552
Self-Image						
Over Wt	-0.2663	0.1196	1.1013*	0.1687	0.4666*	0.0728
Under Wt	0.2948**	0.2046	0.2228	0.2886	-0.0201	0.1245
Female	-0.3926*	0.0955	-2.0846*	0.1347	-0.6544*	0.0581
Age (yrs)	-0.0934*	0.0141	0.1152*	0.0199	0.0682*	0.0086
Age^2	0.0013*	0.0001	-0.0008*	0.0002	-0.0007*	0.0001
Edu (yrs)	0.0331*	0.0148	-0.0809*	0.0209	-0.0412*	0.0090
Income	0.0011	0.0021	0.0009	0.0030	0.0003	0.0013
Married	-0.0808	0.1443	-0.3897*	0.2036	-0.1231**	0.0878
Divorced	-0.1187	0.1760	0.0131	0.2484	0.0483	0.1071
Poor	0.2431*	0.1333	-0.1664	0.1880	-0.1334	0.0811
Black	-0.5792*	0.3012	1.3043*	0.4250	0.6396*	0.1833
White	-0.4692**	0.2902	0.6073**	0.4095	0.3604*	0.1766
Hispanic	-0.3309	0.3017	1.1595*	0.4256	0.5115*	0.1835
Obese	0.9571*	0.1447	-4.4784*	0.2042	-2.0433*	0.0881
Over Wt	0.5676*	0.1253	-2.2769*	0.1768	-1.0178*	0.0762
Under Wt	-0.0654	0.3161	2.3646*	0.4460	0.8818*	0.1923
R^2	0.0736		0.1677		0.1481	

*Statistically different at $\alpha = 0.05$ level.

**Statistically different at $\alpha = 0.10$ level.

Table 4. Sample statistics – equation (3)

Variable	Definition	Mean	Std Dev
Actual BMI	measured body mass index	27.922	6.449
Self-Reported BMI	BMI derived from self-reported weight and height	27.287	6.025
Demographics			
Female	Female =1, otherwise=0	0.518	0.500
Age	Age in years	44.135	21.672
Age^2	Age squared	2,417.450	2092.800
Income	Income in $1,000	43.518	27.741
Married	Married = 1, otherwise=0	0.449	0.497
Divorced	Yes = 1, otherwise = 0	0.181	0.385
College	College Ed = 1, otherwise = 0	0.411	0.492
White	White = 1, otherwise = 0	0.511	0.500
Black	Black =1, otherwise = 0	0.225	0.418
Hispanic	Hispanic = 1, otherwise = 0	0.238	0.426
Food Stamps	Food Stamps for HH = 1, else = 0	0.132	0.339
Dietary and Meal Pattern			
Breakfast	Times ate breakfast (0, 1, 2)	1.632	0.632
%Fat	% of total Kcal from fats	0.334	0.073
%Soft drinks	% of soft drinks in beverages	0.332	0.325
Vitamin	# of different types of vitamins took	1.518	3.718
%LF Milk	% of low-fat milk in total milk	0.421	0.486
%AFH Food	% of total Kcal from food away-from-home	0.323	0.273
Lifestyle			
Exercise (000 MET)	See eq. (2)	5.572	12.063
Smoke	Smoking now = 1; else = 0	0.175	0.380

Table 5. Parameter estimates

	Actual BMI		Self-reported BMI		Difference	
	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
Intercept	17.6834*	0.8728	9.8560*	10.96448	-7.8274	10.8940
Female	-0.1036	0.1877	2.9709	2.3580	3.0744**	2.3428
Age	0.3110*	0.0337	0.8697*	0.4227	0.5587**	0.4200
Age^2	-0.0028*	0.0003	-0.0078*	0.0041	-0.0050	0.0041
Income	-0.0004	0.0038	-0.0321	0.0475	-0.0317	0.0472
Married	-0.1676	0.2623	-0.9689	3.2952	-0.8013	3.2740
Divorced	-0.2803	0.3270	4.9061	4.1072	5.1864	4.0808
White	2.3849*	0.4587	7.2763	5.7621	4.8914	5.7251
Black	4.3717*	0.5261	10.0924**	6.6083	5.7208	6.5658
Hispanic	3.1459*	0.5237	10.6076**	6.5792	7.4617	6.5368
College	-0.3341	0.2003	2.3239	2.5167	2.6580	2.5005
Food Stamps	1.1694*	0.3450	-2.1518	4.3343	-3.3212	4.3064
Breakfast	-0.7820*	0.1581	-3.1947*	1.9858	-2.4126	1.9730
%Fat	5.9291*	0.9585	-9.2531	12.0403	-15.1822	11.9629
%Soft Drinks	2.2612*	0.3179	2.9383	3.9930	0.6771	3.9673
%LF Milk	0.0071	0.2038	-0.0146	2.5607	-0.0218	2.5442
%AFH Food	-0.3446	0.3815	-2.4009	4.7924	-2.0563	4.7616
Vitamin	-0.0871*	0.0245	-0.2707	0.3075	-0.1836	0.3055
Exercise	-0.0444*	0.0122	-0.1470	0.1531	-0.1026	0.1521
Smoking	-1.1908*	0.2210	-3.5599**	2.7767	-2.3691	2.7589
R^2	0.0897		0.0061		0.0050	

*Statistically different from zero at $\alpha = 0.05$ level.

**Statistically different from zero at $\alpha = 0.10$ level.