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Abstract

Objectives

This article compares associations between body mass index (BMI) categories based on self-reported versus measured data with selected health conditions. The goal is to see if the misclassifications resulting from the use of self-reported data alters associations between excess body weight and these health conditions.

Methods

The analysis is based on 2,667 respondents aged 40 years or older from the 2005 Canadian Community Health Survey (CCHS) who, during a face-to-face interview, provided self-reported values for height and weight and were then measured by trained interviewers. Multiple logistic regression analysis was used to examine associations between BMI categories (based on self-reported and measured data) and obesity-related health conditions.

Results

On average, BMI based on self-reported height and weight was 1.3 kg/m^2 lower than BMI based on measured values. Consequently, based on self-reported data, a substantial proportion of individuals with excess body weight were erroneously placed in lower BMI categories. This misclassification resulted in elevated associations between overweight/obesity and morbidity.

Keywords

body mass index, measurement error, misclassification, self-report, sensitivity and specificity, validity

Authors

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Numerous studies from around the world have documented associations between excess body weight and a wide range of chronic conditions, including type 2 diabetes, cardiovascular disease, hypertension, gallbladder disease and certain types of cancer.[1] In these studies, it is common practice to use body mass index (BMI) categories to examine health risks of excess weight. BMI is a measure of an individual's weight in relation to height and is a simple way of measuring excess weight in population health surveys.

When comparing results across studies, the method used to collect information on weight and height should be considered. Some studies are based on data from surveys that directly measured the height and weight of respondents, while other studies are based on self-reported weight and height.[1,2] Conclusions of a recent systematic review of the literature[3] were consistent with recent findings from Canadian data:[4] self-reports tend to underestimate weight and overestimate height. As a result, significant misclassification occurs when BMI categories are estimated from self-reported data. An important question is whether such misclassification alters our understanding of associations between BMI category and obesity-related diseases.

In 2005, the Canadian Community Health Survey (CCHS) collected both self-reported and measured height and weight from a subsample of respondents. Based on these data, this study compares associations between BMI categories and selected health conditions to see if the use of self-reported data alters associations between excess weight and morbidity. The study focuses on the household population aged 40 or older. Before associations between BMI categories and morbidity are examined, the misclassification bias for the study population is summarized.

Methods

Data source

Data are from the 2005 CCHS. The CCHS covers the population aged 12 years or older living in private households. It does not include residents of Indian reserves, institutions and some remote areas; full-time members of the Canadian Forces; and civilian residents of military bases. For the 2005 CCHS, interviews were conducted between January and December 2005. The response rate was 79%, yielding a sample of 132,947 respondents.

Three sampling frames were used to select the sample of households for the 2005 CCHS: 49% of the sample of households came from an area frame; 50% from a list frame of telephone numbers; and the remaining 1% from a Random Digit Dialing (RDD) sampling frame. Owing to cost considerations, measured height and weight were collected for only a subsample ("subsample 2") of respondents, all of whom were from the area frame. Residents of the territories were not included in this subsample.

Since the health conditions considered in this analysis are most prevalent among older adults, the study population was restricted to respondents aged 40 years or older. In total, 4,357 CCHS respondents selected for sub-sample 2 were 40 years or older. Measured height and weight were obtained for 2,711 of them. The main reason for non-response was refusal.

Because measured height and weight were recorded for only a subset of respondents in subsample 2, an adjustment was made to minimize non-response bias. A special sampling weight was created by redistributing the sampling weights of non-respondents to measured height and weight to respondents using response propensity classes. The variables used to create these classes were region (British Columbia, Prairies, Ontario, Quebec, Atlantic provinces), age, sex, household size, marital status, rural/urban indicator, and quarter of collection.

Of the 2,711 respondents for whom measured height and weight were collected, an additional 44 records were excluded from this analysis because they were missing either self-reported height or weight, or were women who were pregnant at the time of the survey. This left 2,667 respondents.

A detailed description of the CCHS methodology is available in a published report.[5]

Analytical techniques

The bias associated with using self-reported data for weight, height and BMI was estimated by calculating the difference between measured and self-reported values (measured minus self-reported value). A positive difference indicates underreporting, and a negative difference, overreporting. Respondents whose measured minus self-reported value was five or more standard deviations from the mean were considered outliers and dropped from the analysis (14 records were dropped for weight, 18 for height, and 23 for BMI).

Respondents were classified into BMI categories (see Definitions). Because of small sample sizes, obese categories II and III were combined. The degree of misclassification that resulted from the use of self-reported values to estimate the prevalence of the various BMI categories was assessed by calculating sensitivity and specificity. Sensitivity refers to the percent of true positives, and specificity, the percent of true negatives. For example, for estimates of obesity (BMI 30 kg/m^2 or more), sensitivity would be the percent of respondents classified as obese based on self-reported values among those classified as obese based on measured values (in other words, the percent of obese people who actually reported that they were obese). Specificity is the percentage of

respondents classified as not obese (BMI less than 30 kg/m^2) based on self-reported values among those who were not obese based on measured values (in other words, the percent of people who reported that they were not obese, among those who actually were not obese).

To study the impact that misclassification of BMI categories has on the association between obesity and selected health conditions, two sets of logistic regression models were fitted. In each set, a total of 12 regression models were fitted—one for each of the 6 health conditions considered, controlling for BMI categories, and one for each of the 6 conditions controlling for continuous BMI. In the first set of models, BMI categories were based on self-reported height and weight, and in the second set, BMI categories were based on measured height and weight. In both sets of models, age and sex were entered as control variables. The purpose was to see if associations between BMI categories and health conditions differed, depending on whether they were based on self-reported or measured values. Both sets of models used data from the same respondents.

All estimates were weighted to represent the household population aged 40 years or older in 2005 (using the weight created to adjust for non-response to measured height and weight in subsample 2). To account for the survey design effect of the CCHS, standard errors, coefficients of variation and 95% confidence intervals were estimated using the bootstrap technique.[6-8] Differences between estimates were tested for statistical significance, which was established at the 0.05 level.

Definitions

Self-reported height and weight were collected with the questions:

- "How tall are you without shoes on?" Categories for height in feet and inches were listed on the questionnaire, with corresponding metric values in brackets. Interviewers were instructed to round up to the closest inch for respondents who reported half inch measures.
- "How much do you weigh?" If asked, interviewers told respondents to report weight without clothing. After reporting their weight, respondents were asked if they had reported in pounds or kilograms. Most respondents (94%) reported in pounds.

CCHS interviewers were trained to measure the height and weight of respondents. Height (with shoes removed) was measured to the nearest 0.5 cm, and weight, to the nearest 0.1 kg. Calibrated weigh scales (ProFit UC-321 made by Lifesource) and measuring tapes were used to ensure accuracy and consistency of measures.

The entire CCHS interview was about 50 minutes long. Self-reported height and weight were collected close to the beginning of the interview, and the measurements were taken near the end.

Body mass index (BMI) is a measure of weight adjusted for height. In this analysis, BMI was derived from both measured and self-reported weight and height. BMI is calculated by dividing weight in kilograms by the square of height in metres. Based on Canadian guidelines,[9] which are in line with those of the World Health Organization,[10] BMI for adults is classified into six categories:

Category	BMI kg/m^2 range
Underweight	(BMI less than 18.5)
Normal weight	(BMI 18.5 to 24.9)
Overweight	(BMI 25.0 to 29.9)
Obese class I	(BMI 30.0 to 34.9)
Obese class II	(BMI 35.0 to 39.9)
Obese class III	(BMI greater than or equal to 40.0)

Respondents were asked about long-term physical conditions that had lasted or were expected to last six months or longer and that had been diagnosed by a health professional. Interviewers read a list of conditions. Conditions considered in this analysis were *diabetes, high blood pressure, heart disease, and arthritis or rheumatism*.

Self-perceived general health was assessed with the question, "In general, would you say your health is: excellent, very good, good, fair or poor?"

To determine *activity limitation*, respondents were asked: "Do you have any difficulty hearing, seeing, communicating, walking, climbing stairs, bending, learning or doing any similar activities?" As well, a series of questions about limitations in various settings was asked: "Does a long-term physical condition or mental condition or health problem reduce the amount or the kind of activity you can

do: at home, at work, or at school or other activities (e.g., transportation or leisure)?" The response categories were "often," "sometimes" or "never." Respondents were classified as having an activity limitation if they replied "often" or "sometimes" to at least one item.

Results

Self-reported and measured values for height and weight differed (Table 1). On average, height was over-reported by 1.1 cm, while weight was under-reported by 2.5 kg. BMI based on self-reported height and weight was, on average, 1.3 kg/m^2 lower than BMI based on measured values.

These systematic reporting errors resulted in extensive misclassification when BMI categories were derived from self-reported values. Misclassification errors were assessed by calculating sensitivity and specificity (Table 2). Sensitivity was high (91%) for those in the normal weight category; in other words, 91% of respondents whose self-reported height and weight put them in the normal weight range, were, indeed, in the normal range based on their measured height and weight. Among the overweight, sensitivity dropped to 69%. Sensitivity was particularly low for the obese categories: 52% for obese class I and 49% for obese class II and III combined. This was the result of a substantial proportion of individuals who were truly obese reporting values for height and weight that placed them in lower BMI categories. For the combined obese group (BMI 30 kg/m^2 or more), sensitivity was 62%, and for the overweight and obese combined (BMI 25 kg/m^2 or more), 83%.

Specificity was very high (95% or more) for the obese categories, indicating that very few respondents reported values for height and weight that placed them in the obese category unless they really were obese.

Given the substantial degree of misclassification that occurs when BMI is derived from self-reported

Table 1
Mean height, weight and body mass index (BMI), by collection method, household population aged 40 years or older, Canada excluding territories, 2005

	Collection method			95% confidence interval of difference
	Measured	Self-reported	Difference†	
Mean height (cm)	167.5	168.6	-1.1	-1.3 to -0.9
Mean weight (kg)	77.9	75.4*	2.5	2.3 to 2.7
Mean BMI (kg/m^2)	27.7	26.4*	1.3	1.2 to 1.4

† measured minus self-reported
* significantly different from measured estimate ($p < 0.05$)
Source: 2005 Canadian Community Health Survey (sub-sample 2).

Table 2
Self-reported body mass index (BMI) category by measured BMI category, household population aged 40 years or older, Canada excluding territories, 2005

	Measured BMI category (range kg/m^2)							
	Normal weight (18.5 to 24.9)		Overweight (25.0 to 29.9)		Obese class I (30.0 to 34.9)		Obese class II/III (35 or more)	
	Total ('000)	%	Total ('000)	%	Total ('000)	%	Total ('000)	%
Self-reported BMI category (range kg/m^2)								
Underweight (less than 18.5)	167	4	1	0	0	0	0	0
Normal weight (18.5 to 24.9)	4,095	91	1,702	29	52	2	3	0
Overweight (25.0 to 29.9)	254	6	4,044	69	1,523	46	99	9
Obese class I (30.0 to 34.9)	0	0	143	2	1,694	52	451	42
Obese class II/III (35.0 or more)	0	0	0	0	13	0	521	49
Total	4,516	100	5,889	100	3,282	100	1,074	100
Sensitivity								
% true positives (95% confidence interval)	91 (87 to 94)		69 (65 to 73)		52 (44 to 59)		49 (39 to58)	
Specificity								
% true negatives (95% confidence interval)	82 (80 to 85)		79 (76 to 83)		95 (93 to 96)		100 (100 to 100)	

Note: Sensitivity and specificity estimates are not given for the measured underweight group (BMI less than 18.5) because of small sample sizes.
Source: 2005 Canadian Community Health Survey (sub-sample 2).

height and weight, it is important to determine if associations between BMI categories and various health conditions are different when BMI is derived from self-reported rather than measured data. Results of the regression analyses comparing associations between BMI categories and health conditions reveal that the odds ratios for the overweight and obese categories were generally higher for models based on self-reported values than the odds for models based on measured values (Table 3). In several cases, the differences were substantial. For example, the odds ratios for diabetes for the overweight, obese I, and obese II/III categories, were 2.6, 3.2, and 11.8, respectively, in the model based on self-reported data; the corresponding odds ratios in the model based on measured values were 1.4, 2.2 and 7.0.

The explanation for these differences becomes clear when the average weight in each BMI category based on measured values is compared with that based on self-reported values (Table 4). According to measured values, 22% of respondents were classified as obese I and 7% as obese II/III, with average weights of 91 kg and 106 kg, respectively. According to self-reported values, far fewer respondents were classified into these categories (15% obese I; 4% obese II/III), but their average measured weight was substantially greater: 95 kg for obese I and 113 kg for obese II/III. As a result, stronger associations with morbidity were observed for overweight and obese categories based on self-reported data because the respondents in them are, in fact, heavier.

Table 3
Adjusted odds ratios relating measured and self-reported body mass index (BMI) to selected health conditions, household population aged 40 years or older, Canada excluding territories, 2005

	Based on measured BMI		Based on self-reported BMI	
BMI category (range kg/m²)	Adjusted odds ratios	95% confidence interval	Adjusted odds ratios	95% confidence interval
Diabetes				
Normal weight (18.5 to 24.9)	1.0	...	1.0	...
Overweight (25.0 to 29.9)	1.4	0.7 to 2.9	2.6*	1.6 to 4.3
Obese class I (30.0 to 34.9)	2.2*	1.0 to 4.5	3.2*	1.8 to 5.6
Obese class II/III (35.0 or more)	7.0*	2.9 to 16.5	11.8*	5.5 to 25.3
BMI (continuous)	1.11*	1.07 to 1.16	1.13*	1.09 to 1.18
High blood pressure				
Normal weight (18.5 to 24.9)	1.0	...	1.0	...
Overweight (25.0 to 29.9)	2.1*	1.5 to 3.0	2.7*	1.9 to 3.8
Obese class I (30.0 to 34.9)	3.4*	2.3 to 5.1	4.3*	2.9 to 6.3
Obese class II/III (35.0 or more)	5.5*	3.1 to 9.8	7.8*	3.7 to 16.6
BMI (continuous)	1.12*	1.09 to 1.15	1.14*	1.11 to 1.17
Heart disease				
Normal weight (18.5 to 24.9)	1.0	...	1.0	...
Overweight (25.0 to 29.9)	1.0	0.6 to 1.7	1.4	0.9 to 2.3
Obese class I (30.0 to 34.9)	1.5	0.8 to 2.9	1.6	1.0 to 2.6
Obese class II/III (35.0 or more)	2.6*	1.1 to 6.0	5.6*	2.3 to 13.8
BMI (continuous)	1.07*	1.02 to 1.12	1.08*	1.03 to 1.14
Arthritis				
Normal weight (18.5 to 24.9)	1.0	...	1.0	...
Overweight (25.0 to 29.9)	1.2	0.8 to 1.7	1.2	0.8 to 1.7
Obese class I (30.0 to 34.9)	1.2	0.8 to 1.8	2.0*	1.3 to 3.0
Obese class II/III (35.0 or more)	2.9*	1.7 to 4.8	3.5*	1.7 to 7.1
BMI (continuous)	1.05*	1.03 to 1.08	1.07*	1.04 to 1.11
Activity limitation				
Normal weight (18.5 to 24.9)	1.0	...	1.0	...
Overweight (25.0 to 29.9)	1.2	0.9 to 1.6	1.2	0.9 to 1.6
Obese class I (30.0 to 34.9)	1.5*	1.1 to 2.2	2.0*	1.3 to 3.0
Obese class II/III (35.0 or more)	3.0*	1.8 to 4.9	4.7*	2.5 to 8.9
BMI (continuous)	1.06*	1.04 to 1.08	1.07*	1.04 to 1.10
Fair/poor self-perceived health				
Normal weight (18.5 to 24.9)	1.0	...	1.0	...
Overweight (25.0 to 29.9)	0.8	0.5 to 1.2	1.3	0.9 to 2.0
Obese class I (30.0 to 34.9)	1.7*	1.0 to 2.7	2.8*	1.8 to 4.3
Obese class II/III (35.0 or more)	3.2*	1.8 to 5.6	5.4*	2.5 to 11.6
BMI (continuous)	1.09*	1.06 to 1.12	1.10*	1.06 to 1.14

* significantly different from estimate for normal weight category ($p < 0.05$)
... not applicable
Notes: Models control for age (continuous) and sex. Odds ratios for underweight group are not reported because of small sample sizes.
Source: 2005 Canadian Community Health Survey (sub-sample 2).

Table 4
Mean measured weight (kg) and mean measured body mass index (BMI kg/m²), by BMI category based on measured and on self-reported values, household population aged 40 years or older, Canada excluding territories, 2005

	%	Mean measured weight (kg)	Mean measured BMI (kg/m²)
BMI category (range kg/m²) based on measured values			
Normal weight (18.5 to 24.9)	30.3	63.3	22.6
Overweight (25.0 to 29.9)	39.6	77.4	27.3
Obese class I (30.0 to 34.9)	22.0	90.8	31.9
Obese class II/III (35.0 or more)	7.2	106.1	39.6
BMI category (range kg/m²) based on self-reported values			
Normal weight (18.5 to 24.9)	39.8*	65.8*	23.6*
Overweight (25.0 to 29.9)	39.8	81.4*	28.6*
Obese class I (30.0 to 34.9)	15.4*	94.5*	33.3*
Obese class II/III (35.0 or more)	3.6*	112.8*	42.3*

* significantly different from estimate for corresponding BMI category based on measured values ($p < 0.05$)
Source: 2005 Canadian Community Health Survey (sub-sample 2).

The two sets of models (for each condition) were also run using BMI as a continuous variable. The differences between regression coefficients for BMI for the two sets of models were small, but in all cases, the set of models based on self-reported data had slightly higher regression coefficients.

Discussion

This study of a representative sample of the Canadian population aged 40 years or older found that systematic over-reporting of height and under-reporting of weight caused substantial misclassification of people by BMI category, compared with results based on measured values. The finding that self-reported data overestimate height and underestimate weight is consistent with numerous other studies.[3] Few studies, however, have sought to determine if reporting biases in height and weight alter associations between BMI categories and morbidity.

In this analysis, the misclassification that occurred when BMI categories were derived from self-reported data resulted in *elevated* associations between the overweight and obese categories and obesity-related health conditions. Contrary to these findings, a study of Mexican adults found that the use of BMI categories based on self-reported data underestimated the associations between excess body weight and asthma among men.[11] However, the findings of a study of Greek adults were consistent with those in this analysis: the use of self-reported data resulted in stronger associations between obesity and diabetes, hypercholesterolemia, and high blood pressure.[12]

Based on self-reported data, this analysis found far fewer respondents being classified as overweight or obese. However, those whose self-reported height and weight placed them in the overweight or obese categories had substantially higher BMIs, on average, than did people assigned to these categories based on measured data.

Although associations with obesity-related conditions for the overweight and obese categories were exaggerated when based on self-reported data, this does not imply that the disease burden (the number of cases) is overestimated. In fact, the total burden is underestimated because of the underestimation of the prevalence of overweight and obesity. For example, among those classified as obese based on self-reported data, 360,000 people aged 40 years or older had diabetes. But among those classified as obese based on measured values, 530,000 people (nearly 50% more) had diabetes (data not shown). These differences simply reflect the greater number of people who are classified as obese when measured data are used.

It has often been proposed that using BMI as a continuous variable in analytical studies based on self-reported data can avoid the problem of the misclassification of BMI categories (because of the very high correlations between self-reported and measured height and weight). However, the use of BMI as a continuous variable assumes a linear association between BMI and morbidity, an assumption that has been challenged by recent research in the United States.[13] Moreover, using BMI as a continuous variable precludes the possibility of quantifying the degree to which the risk of disease differs among specific sub-groups with excess body weight. The report by Flegal et al.[13] examined associations between BMI categories based on measured data and cause-specific mortality. Compared with the normal weight group, the overweight group had similar risks of mortality from cancer and cardiovascular disease (CVD), and decreased risks of mortality from non-cancer, non-CVD causes. Obesity was associated with an increased risk of mortality from CVD and some cancers, but was not associated with non-cancer, non-CVD mortality. It would not have been possible to observe such distinctions of mortality risk for different BMI categories if BMI had been used as a continuous measure, and these distinctions would likely have been masked if BMI categories had been based on self-reported values.

Other approaches that have been suggested when dealing with self-reported data are to lower BMI cut-points for overweight and obesity, or to adjust self-reported values to account for the reporting bias. Several studies have evaluated the possibility of using linear regression to predict measured values (of height, weight and BMI) using self-reported values and other variables such as age. Although a

study based on data from the United States collected during the late 1970s concluded that it was difficult or impossible to correct for reporting bias using linear regression,[14] more recent efforts (based on populations in which reporting bias was higher) have had greater success in using prediction equations to adjust self-reported values to produce estimates with higher levels of sensitivity.[15-17] A feasibility study using data from the 2005 CCHS is currently underway to assess the possibility of producing prediction equations to correct for the bias in self-reported data in the Canadian population. This is particularly important given the very low sensitivity of obesity estimates derived from self-reported data. But even if self-reported values can be adjusted to correct for bias, it will still be necessary to monitor reporting bias over time to determine the need for ongoing adjustments to the equations.

Limitations

This study compared health risks of excess body weight for BMI categories calculated from measured weight and height with health risks for BMI categories calculated from self-reported data obtained in face-to-face interviews. Self-reported data from face-to-face interviews yield higher prevalence estimates of obesity than do data collected in telephone interviews.[18] Therefore, studies based on data collected by telephone may further exaggerate associations between excess body weight and morbidity. Caution is necessary when extending the findings of this analysis to studies that employed other modes of data collection (telephone, mail).

Although this analysis considered measured height and weight to be "true" values, some factors may have limited their accuracy. Height and weight were measured by trained Statistics Canada interviewers; measures made by trained health technicians that have been used in other studies may be more accurate.[19,20] Although identically calibrated weigh scales and measuring tapes were used by the interviewers, validity and reliability studies to assess inter- and intra-interviewer accuracy and reproducibility were not performed.

Some of the bias associated with under-reporting weight may be due to clothing. Respondents were weighed fully clothed, but people may weigh themselves at home with minimal or no clothing. If interviewers were asked, they told respondents to report their weight without clothing.

Because only a small number of respondents' measured height and weight placed them in the underweight category, it was not possible to determine if the use of self-reported data altered associations with morbidity for this group.

Conclusion

The practice of collecting self-reported data for height and weight is a fiscal necessity for large-scale health surveys conducted at Statistics Canada such as the Canadian Community Health Survey (CCHS) and the National Population Health Survey (NPHS). Users of CCHS and NPHS data should be aware that the misclassification of BMI categories that results from self-reported data may exaggerate associations between overweight/obesity and morbidity and underestimate the obesity-related

Why is this study important?

- The practice of collecting self-reported data for height and weight is a fiscal necessity for large-scale health surveys conducted at Statistics Canada.
- It is important to examine the extent to which the use of self-reported data alters our understanding of the associations between excess body weight and morbidity.

What else is known on this topic?

- Many studies have found that self-reported data yield lower estimates of the prevalence of obesity, compared with estimates based on measured data, but few studies have examined the effect of the misclassification bias on the relationship between BMI categories and obesity-related health conditions.

What does this study add?

- Misclassification that occurred when BMI categories were derived from self-reported data resulted in erroneously elevated associations between overweight and obesity and obesity-related health conditions.

burden of disease. Therefore, researchers may want to consider adjusting self-reported values or lowering BMI cut-points for the overweight and obese categories when examining associations between excess body weight and obesity-related health conditions. It will be important to monitor the magnitude of the bias over time to see if revisions to correction factors are required. ●

References

1. World Health Organization. *Obesity: Preventing and Managing the Global Epidemic (WHO Technical Report Series, No. 894)*. Geneva: World Health Organization, 2000.
2. Canadian Institute for Health Information. *Overweight and Obesity in Canada: A Population Health Perspective*. Ottawa: Canadian Institute for Health Information, 2004.
3. Connor Gorber S, Tremblay M, Moher D, et al. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obesity Reviews* 2007; 8(4): 307-26.
4. Shields M, Connor Gorber S, Tremblay M. Estimates of obesity based on self-report versus direct measures. *Health Reports* (Statistics Canada, Catalogue 82-003) 2008; 19(2): ??
5. Béland Y. Canadian Community Health Survey - Methodological overview. *Health Reports* (Statistics Canada, Catalogue 82-003) 2002; 13(3): 9-14.
6. Rao JNK, Wu CFJ, Yue K. Some recent work on resampling methods for complex surveys. *Survey Methodology* (Statistics Canada, Catalogue 12-001) 1992; 18(2): 209-17.
7. Rust KF, Rao JNK. Variance estimation for complex surveys using replication techniques. *Statistical Methods in Medical Research* 1996; 5: 281-310.
8. Yeo D, Mantel H, Liu TP. Bootstrap variance estimation for the National Population Health Survey. *Proceedings of the Annual Meeting of the American Statistical Association, Survey Research Methods Section, August 1999*. Baltimore: American Statistical Association, 1999.
9. Health Canada. *Canadian Guidelines for Body Weight Classification in Adults*. (Catalogue H49-179). Ottawa: Health Canada, 2003.
10. World Health Organization. *Physical Status: The Use and Interpretation of Anthropometry, Report of the WHO Expert Committee (WHO Technical Report Series, No. 854)*. Geneva: World Health Organization, 1995.
11. Santillan AA, Camargo CA. Body mass index and asthma among Mexican adults: the effect of using self-reported vs measured weight and height. *International Journal of Obesity and Related Metabolic Disorders* 2003; 27(11): 1430-3.
12. Yannakoulia M, Panagiotakos DB, Pitsavos C, et al. Correlates of BMI misreporting among apparently healthy individuals: the ATTICA study. *Obesity* 2006; 14(5): 894-901.
13. Flegal KM, Graubard BI, Williamson DF, et al. Cause-specific excess deaths associated with underweight, overweight, and obesity. *JAMA* 2007; 298(17): 2028-37.
14. Plankey MW, Stevens J, Flegal KM, et al. Prediction equations do not eliminate systematic error in self-reported body mass index. *Obesity Research* 1997; 5(4): 308-14.
15. Nyholm M, Gullberg B, Merlo J, et al. The validity of obesity based on self-reported weight and height: Implications for population studies. *Obesity (Silver Spring)* 2007; 15(1): 197-208.
16. Spencer EA, Appleby PN, Davey GK, et al. Validity of self-reported height and weight in 4808 EPIC-Oxford participants. *Public Health Nutrition* 2002; 5(4): 561-5.
17. Kuskowska-Wolk A, Bergstrom R, Bostrom G. Relationship between questionnaire data and medical records of height, weight and body mass index. *International Journal of Obesity* 1992; 16(1): 1-9.
18. Béland Y, St-Pierre M. Mode effects in the Canadian Community Health Survey: a comparison of CATI and CAPI. In: Lepkowski J, Tucker C, Brick JM, et al., eds. *Advances in Telephone Survey Methodology*. New York, N.Y.: Wiley, 2008: 297-314.
19. Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of age on validity of self-reported height, weight, and body mass index: findings from the Third National Health and Nutrition Examination Survey, 1988-1994. *Journal of the American Dietetic Association* 2001; 101(1): 28-34.
20. Rowland ML. Reporting bias in height and weight data. *Statistical Bulletin of the Metropolitan Insurance Company* 1989; 70(2): 2-11.