Similarity in Percent Body Fat Between White and Vietnamese Women: Implication for a Universal Definition of Obesity

[Q1] Lan T. Ho-Pham[1], Thai Q. Vu[1], Nguyen D. Nguyen[2], Elizabeth Barrett-Connor[3] and Tuan V. Nguyen[2,4]

[Q2] **It has been widely assumed that for a given BMI, Asians have higher percent body fat (PBF) than whites, and that the BMI threshold for defining obesity in Asians should be lower than the threshold for whites. This study sought to test this assumption by comparing the PBF between US white and Vietnamese women. The study was designed as a comparative cross-sectional investigation. In the first study, 210 Vietnamese women ages between 50 and 85 were randomly selected from various districts in Ho Chi Minh City (Vietnam). In the second study, 419 women of the same age range were randomly selected from the Rancho Bernardo Study (San Diego, CA). In both studies, lean mass (LM) and fat mass (FM) were measured by dual-energy X-ray absorptiometry (DXA) (QDR 4500; Hologic). PBF was derived as FM over body weight. Compared with Vietnamese women, white women had much more FM (24.8 ± 8.1 kg vs. 18.8 ± 4.9 kg; $P < 0.0001$) and greater PBF (36.4 ± 6.5% vs. 35.0 ± 6.2%; $P = 0.012$). However, there was no significant difference in PBF between the two groups after matching for BMI (35.1 ± 6.2% vs. 35.0 ± 5.7%; $P = 0.87$) or for age and BMI (35.6 ± 5.1% vs. 35.8 ± 5.9%; $P = 0.79$). Using the criteria of BMI ≥30, 19% of US white women and 5% of Vietnamese women were classified as obese. Approximately 54% of US white women and 53% of Vietnamese women had their PBF >35% ($P = 0.80$). Although white women had greater BMI, body weight, and FM than Vietnamese women, their PBF was virtually identical. Further research is required to derive a more appropriate BMI threshold for defining obesity for Asian women.**

Obesity (2010) doi:10.1038/oby.2010.19

INTRODUCTION

Although obesity is recognized as a global public health problem, the extent of obesity is a matter of contention, due largely to a lack of consensus regarding definition. Clinically, obesity is defined as a condition characterized by excessive body fat to the extent that it is harmful to well being and health (1). Currently, the operational definition of obesity is based on BMI. According to the World Health Organization criteria, any individual whose BMI ≥30 kg/m^2 is considered obese (2). Although BMI is widely used in the diagnosis of obesity, it has been criticized because it does not distinguish between fat mass (FM), muscle mass, bone and vital organs (3–8).

It has been argued that a better classification of obesity should be based on percent body fat (PBF), in which any woman whose PBF >35% and any man whose PBF >25% is considered obese (9). Using the relationship between BMI and PBF, it has been suggested that in Asian populations, a BMI ≥25 should be classified as obese (10), because a BMI of 25 kg/m^2 is assumed to correspond to about 25 and 35% body fat for Asian men and women, respectively (9). This classification is based on the assumption that for a given BMI, Asians have greater PBF than whites (11,12). However, a close examination of the data on which this assumption is based on (12) reveals little difference in PBF between Chinese in New York and white women. In this article, we examine the validity of this assumption by comparing PBF between white American women of European ancestry and Vietnamese women living in Vietnam.

METHODS AND PROCEDURES

Study design and participants

This study was designed as a comparative observational investigation that involved two populations, one in Ho Chi Minh City (Vietnam) and one San Diego (United States). Study design and details of data collection have been described elsewhere (13,14).

The Vietnamese study was part of a cross-sectional study designed to examine the effect of veganism on bone health. We randomly selected 20 temples and monasteries in Ho Chi Minh City, and then sent a letter of invitation to all nuns aged ≥50 to participate in the study. In the next step, we randomly sampled households around each temple or monastery, and a similar letter of invitation was sent out to female members of the

[Q3] [1]Department of Internal Medicine, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam; [2]Osteoporosis and Bone Biology Program, Garvan Institute of Medical Research, St Vincent's Hospital, Sydney, Australia; [3]Department of Family Medicine, UCSD School of Medicine, San Diego, California, USA; [4]Faculty of Medicine, The University of New South Wales, Sydney, Australia. Correspondence: Lan T. Ho-Pham (thuclanhopham@pnt.edu.vn)

Received 8 September 2009; accepted 13 January 2010; advance online publication 00 Month 2010. doi:10.1038/oby.2010.19

households. None of the participants had any diseases deemed to affect osteoporosis (such as hyperthyroidism, hyperparathyroidism, renal failure, malabsorption syndrome, alcoholism, chronic colitis, multiple myeloma, leukemia, and chronic arthritis) or previous use of therapies that interfere with bone metabolism (e.g., glucocorticosteroids, heparin, warfarin, thyroxine, and estrogen). The study was approved by the ethics committee of the Pham Ngoc Thach University of Medicine, and informed consent was obtained from all participants. The measurements had taken place between March 2008 and August 2008.

The Rancho Bernardo Study is a prospective population-based study, in which 82% of adult residents of Rancho Bernardo, a geographically defined Southern California community, were enrolled in the study. The participants were middle-class whites, primarily of European ancestry, and aged ≥55 years. About 80% of surviving noninstitutionalized and locally resident participants returned for additional evaluations about every 4 years. The Rancho Bernardo Study was approved by the institutional review board of the University of California, San Diego, CA, and informed consent was obtained. Data for the present study were collected between January 2000 and August 2003.

In both studies, age, weight, and standing height were measured using the same methods. Body weight was measured by using a balance beam scale in participants wearing indoor lightweight clothing without shoes. Height without shoes was measured by a stadiometer with mandible plane parallel to the floor. BMI was derived as the ratio of weight (in kilograms) and height (in meters squared).

Body composition measurements

In both studies, lean mass (LM), FM, and bone mineral density were measured by the dual-energy X-ray absorptiometry densitometer (DXA QDR 4500; Hologic, Waltham, MA) with a standard adult whole body scan mode. The Vietnam site used the Hologic software version 12.6, whereas the US site used the software version 12.3. The DXA instruments in the US and Vietnam were standardized by a Hologic-designed whole body phantom. The phantom includes six white high-density polyethylene rectangle, and a sheet of polyvinylchloride is bonded to high-density polyethylene rectangle to mimic FM.

We expressed FM in two ways. First, we used the "traditional" PBF that was derived as the ratio of FM over body weight. Second, because body size is associated with all of these measures, we derived the FM index (FMi) by the following formula: $FMi = FM/(height)^k$, where height is expressed in meters. The power constant k was derived by fitting the linear equation of log FM against height: $\log(FM) = a + k \times \log(height)$. Using the observed data from our study, we found $k = 1.96$. Thus, $FMi = FM/(height)^2$ was calculated, a ratio similar to the calculation of BMI.

Analysis

Our objective was to compare PBF between American and Vietnamese women after adjusting for age and body size. We made the comparison between US white and Vietnamese women in two approaches: unmatched and matched analyses. In the first approach, we applied the analysis of covariance model, in which PBF was the outcome, with age and weight being covariates. In the second approach, each Vietnamese woman was matched with a US white woman for age and BMI. We used the "greedy matching algorithm" (as implemented in a SAS macro by the Mayo Clinic) for matching data (15). The two groups were exactly matched for age and BMI. The difference in PBF between the two groups was compared by a mixed-effects analysis, without adjustment for age and BMI. Both analyses were performed with the R language on the Windows XP platform (16).

RESULTS

Unmatched analysis

On average, the California white women were older than the Vietnamese women (71.5 years vs. 62 years) and had significantly greater weight, height, BMI, bone mineral density, LM, and FM than Vietnamese women. Although white women had a greater FM (24.8 ± 8.1 kg; mean ± s.d.) than Vietnamese women (18.8 ± 4.9 kg; $P = 0.012$), however, there was little difference in PBF between the two groups (36.4 ± 6.5% vs. 35.0 ± 6.2%). In absolute measurement, trunk fat in US white women was significantly higher than that in Vietnamese women. However, when trunk fat was expressed as percentage of total FM, Vietnamese women had a greater percent trunk fat than US white women (**Table 1**).

Using the categorical definition of obesity based on BMI ≥30 kg/m^2, 19% ($n = 81/419$) of the white women were obese, and obesity was significantly more common than in Vietnamese women whose prevalence was 4.7% ($n = 10/210$). Nevertheless, 65% white women and 53% of Vietnamese women had PBF >35 (**Table 2**).

The relationship between PBF and BMI was linear, with the regression equation: PBF = 9.53 + 1.05 × BMI for US white

Table 1 Basic characteristics of participants

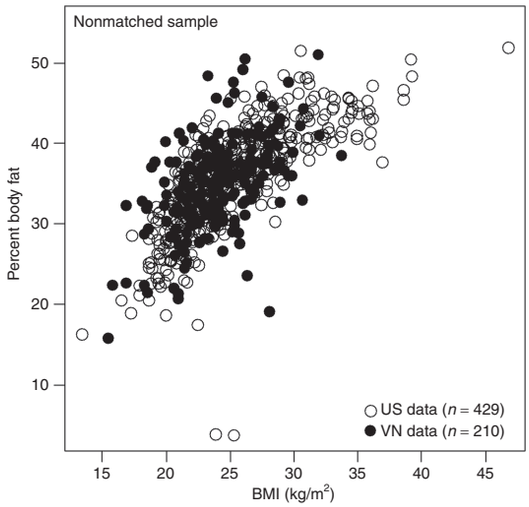
Variable	US white ($n = 419$)	Vietnamese ($n = 210$)	P value
Age (years)	71.5 (8.1)	61.7 (9.6)	<0.0001
Weight (kg)	66.7 (12.9)	53.3 (7.9)	<0.0001
Height (cm)	160.8 (6.1)	148.9 (5.7)	<0.0001
BMI (kg/m^2)	25.8 (4.8)	24.1 (3.2)	<0.0001
Femoral neck BMD (g/cm^2)	0.69 (0.12)	0.63 (0.11)	<0.0001
Lumbar spine BMD (g/cm^2)	0.98 (0.19)	0.76 (0.14)	<0.0001
Whole body BMD (g/cm^2)	1.05 (0.13)	0.89 (0.11)	<0.0001
Lean mass (kg)	38.6 (5.4)	32.3 (4.1)	<0.0001
Lean mass index (kg/m^2)	14.8 (1.8)	14.6 (1.5)	0.0730
Fat mass (kg)	24.8 (8.1)	18.8 (4.9)	<0.0001
Percent body fat (%)	36.4 (6.5)	35.0 (6.2)	0.0122
Fat mass index (kg/m^2)	9.5 (3.1)	8.5 (2.1)	<0.0001
Trunk fat (kg)	11.3 (4.2)	9.8 (2.7)	<0.0001
Trunk fat as percent of total fat (%)	46.9 (5.8)	51.7 (5.5)	<0.0001

Values are mean (s.d.). Lean mass index = lean mass/height^2; fat mass index = fat/height^2 (see Methods and Procedures).
BMD, bone mineral density.

Table 2 Prevalence of "obesity" in Vietnamese and American women ages 50–85 years by various criteria

Criteria	US white ($n = 419$)	Vietnamese ($n = 210$)
BMI ≥25	54.2 (227)	39.1 (82)
BMI ≥30	19.3 (81)	4.8 (10)
Percent body fat ≥35	64.6 (226)[a]	52.9 (111)

Values are percent (number for each category).
[a]$n = 350$, data in percent body fat were not available in 69 participants of the US white data.



[Q4] **Figure 1** Percent body fat and BMI in US white (open circles) and Vietnamese women (closed circles). Data are from the nonmatched [Q5] sample. VN, Vietnam.

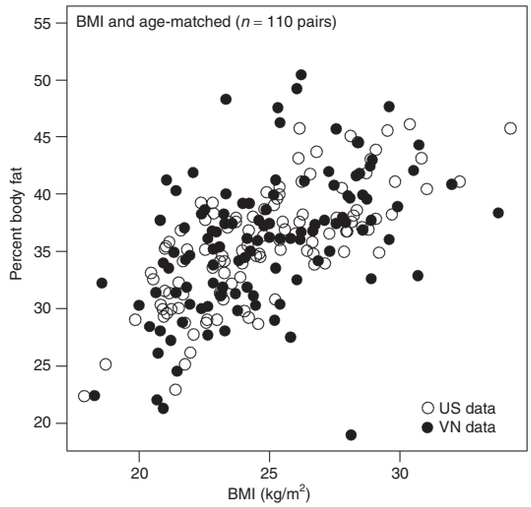


Figure 2 Percent body fat and BMI in US white (open circles) and Vietnamese women (closed circles). Data are from the age and BMI. VN, Vietnam.

Table 3 Percent body fat stratified by BMI category and population

BMI (kg/m²) category	US white (*n* = 419)	Vietnamese (*n* = 210)	*P* value
Unadjusted			
<25	32.0 (5.4)	33.3 (6.8)	0.061
25–29	38.6 (4.6)	37.2 (5.3)	0.083
>29	43.4 (3.2)	40.8 (5.6)	0.183
Adjusted for age			
<25	31.8 (5.8)	33.5 (5.4)	0.001
25–29	38.5 (5.6)	37.5 (5.3)	0.240
>29	43.3 (5.8)	40.9 (5.1)	0.172

Values are mean (s.d.)

Table 4 Summary data for white and Vietnamese women matched by age and BMI

Variable	US white (*n* = 110)	Vietnamese (*n* = 110)	*P* value
Age (years)	67.1 (8.9)	67.1 (8.9)	—
BMI (kg/m²)	24.8 (3.1)	24.8 (3.1)	—
Weight (kg)	64.9 (9.4)	54.0 (8.1)	<0.0001
Height (cm)	161.9 (6.1)	147.5 (5.7)	<0.0001
Femoral neck BMD (g/cm²)	0.71 (0.12)	0.60 (0.11)	<0.0001
Lumbar spine BMD (g/cm²)	1.00 (0.18)	0.71 (0.13)	<0.0001
Whole body BMD (g/cm²)	1.08 (0.13)	0.85 (0.10)	<0.0001
Lean mass (kg)	38.5 (4.4)	32.2 (4.1)	<0.0001
Lean mass index (kg/m²)	14.7 (1.3)	14.8 (1.5)	0.4340
Fat mass (kg)	23.4 (6.1)	19.6 (5.2)	<0.0001
Percent body fat	35.6 (5.1)	35.8 (5.9)	0.7890
Fat mass index (kg/m²)	8.9 (2.2)	8.9 (2.2)	0.8690

Values are mean (s.d.). Lean mass index = lean mass/height²; fat mass index = fat/height² (see Methods and Procedures).
BMD, bone mineral density.

women, and PBF = 14.81 + 0.85 × BMI for Vietnamese women (**Figure 1**); these two slopes did not differ significantly (P = 0.18). For a given category of BMI, there was no significant difference in PBF between white and Vietnamese women (**Table 3**) (for BMI >25, white women actually had a slightly higher PBF than Vietnamese women, but the difference was not statistically significant). When the analysis was adjusted for age, among those with BMI ≤25 kg/m², Vietnamese women had a significantly higher PBF than US white women (33.5% vs. 31.8%; P = 0.001); however, among those whose BMI ≥25, US white women tended to have greater PBF than Vietnamese women, but the difference was not statistically significant (P = 0.24).

Matched analysis

In this analysis, we performed a 1:1 matched-pair analyses, in which each Vietnamese woman was matched by age and BMI with an American woman. This resulted in 110 pairs as shown in **Table 4**. For a given age and BMI, white women had greater height and body weight than Vietnamese women (**Figure 2**). White women also had greater bone mineral density, FM, and LM than Vietnamese women. However, there was no significant difference in PBF or FMi between white and Vietnamese women (average difference in PBF: 0.20%, 95% confidence interval: −0.94 to 1.33%; P = 0.79).

DISCUSSION

In 1994, it was reported that Chinese individuals living in New York City had higher PBF but lower BMI than whites (12). However, a close reading of the data in that paper reveals that there was only a slight difference in PBF between the two

groups (31.6% in Chinese women and 30.1% in white women, $P = 0.08$); even after adjusting for BMI, there was virtually no difference in PBF between the two groups among those with BMI >28 kg/m^2 (12). A subsequent study reported that for a given level of BMI, Indonesians had higher PBF than Dutch (17), but there was no significant difference in PBF between Dutch in the Netherlands and Chinese in Beijing (18). Nevertheless, it has since been assumed that Asian women have higher PBF than white women leading to different standards for optimal BMI levels (11). The present study's result challenges that assumption. We have shown here that postmenopausal Vietnamese have equivalent or lower PBF than US white women, either before or after adjusting for body size.

Because Asians tend to have smaller body size than whites, and because FM is associated with body size, any unbiased comparison of FM between ethnicities should be adjusted for body size. Traditionally, FM has been normalized by body weight to yield PBF, but this normalization can be questioned (19). The derivation of PBF is implicitly based on the assumption that FM varies as a fixed proportion of body weight (20) in the form of FM = $k \times$ weight. In other words, the assumption states that the relation between FM and weight is linear and passes through the origin. But in real world, this assumption is rarely satisfied because the relation between FM and weight is characterized by the equation FM = $a + k \times$ weight. Therefore, dividing both sides by weight will yield PBF = a/weight + k, and which suggests that no constant of proportionality exists. In other words, normalization of FM by weight does not remove the effect of body size.

In this study, we chose height, rather than weight, as a proxy for body size, because the correlation between FM and height ($r = 0.25$) is lower than the correlation between FM and weight ($r = 0.80$). We derived the FMi similar to the BMI. In this study, there was no significant difference in FMi between US white and Vietnamese women.

This finding has important implication for the definition of obesity in Asian populations. Based on the assumption that Asians have higher PBF than whites for a given BMI (11,12) and further assumption that the relation between BMI and PBF depends on age, sex, and ethnicity (9,12,17,21), it has been argued that the BMI cutoff value for the diagnosis of obesity in Asians should be lower than the cut-point for whites (22). It has been estimated that a BMI of 22.6 in women corresponded to a PBF of 35% (23); however, most previous studies have used BMI greater or equal to 25 as a criterion for defining obesity in Asians (10) because a BMI of 25 kg/m^2 is assumed to correspond to about 25 and 35% body fat for Asian men and women, respectively (9).

In contrast with that assumption, we found that the slope of association between FM and BMI in the US white group (1.05) is similar to that in Vietnamese women (slope = 0.85). With that association, we found that a BMI of 24 kg/m^2 corresponded to a PBF of 35% in both US white and Vietnamese women. Therefore, it seems the call for ethnic-specific BMI cutoff value for defining obesity is premature (24).

The ultimate goal of finding an "optimal" BMI cutoff value is to identify high-risk individuals for intervention, clinical counseling, and public health policy-making. In 1993, based on the association between BMI and the risk of diabetes and cardiovascular diseases (25), a WHO (World Health Organization) (world expert panel proposed BMI cutoff points of >30 for obesity (26) in all ethnicities, which is similar to the Metropolitan Life Insurance table results for whites on which "optimal" BMI cutoff value has been based. However, mortality seems to be a better outcome for defining obesity because mortality is a unique and precise end point that can easily be assessed. A number of prospective studies in Asian populations found increased risk of mortality in individuals with BMI >30, but no increased risk of mortality among men and women with BMI within the range of 18.5 and 25 (27). In a major study in China that involved 68,116 men and 86,620 women ages ≥40 years, the risk of mortality in both sexes increased abruptly among those whose BMI was ≥30 kg/m^2 (28). Taken together, these data consistently suggest that the BMI cutoff value of 30 seems appropriate for defining obesity in Asians as well. Based on BMI ≥30 as criteria for defining obesity, in this study ~19% US white women and ~5% Vietnamese women were obese. The prevalence of obesity in Vietnamese women in this study is also highly comparable to the study in the Chinese population by Gu *et al.* (28), in which 4.1% of women had BMI >30.

The present study's findings should be interpreted within the context of potential strengths and weaknesses. The Vietnamese were randomly drawn from the general population to ensure its external validity, and the Rancho Bernardo cohort represented 82% of a geographically defined community. The DXA measurements of FM, LM, and bone mass are accurate and reliable measures of body composition, made by trained densitometrists using the same model regularly calibrated DXA instruments, which enhance the internal validity of the study. The analysis of FM was rigorously adjusted for body size, intended to decrease bias created by differences in body size. Although the Hologic QDR 4500A tends to underestimate FM by about 5% (29), the underestimation did not explain the relative difference in FM between the US white and Vietnamese women, in that using the adjusted equation provided by Schoeller *et al.* (29) showed that the "corrected" FM in US white women was 5.6 kg higher than that in Vietnamese women, after adjusting for age and BMI. It should be noted that although Vietnamese are genetically similar to southern Chinese or other Southeast Asians, their lifestyles and nutritional status likely differ, requiring other data with similar quality measures in these populations. Participants in the Rancho Bernardo Study were of middle to upper socioeconomic status, and differ in many ways from the Vietnamese women. The study design was cross-sectional; therefore, it is not possible to assume causality about the relationship between FM and BMI.

In summary, these data suggest that although white women have greater body weight and FM than Vietnamese women, their PBF is similar. The data also suggest that the association between PBF and BMI in white and Vietnamese women is similar. Definitions of normal or optimal fat levels for defining

obesity in Asian populations still require prospective studies of longevity or clinical outcomes.

ACKNOWLEDGMENTS

We express our great appreciation to Phuong L.T. Nguyen, Tu T.T. Le, Tuyet A.T. Doan, and Ngoc T. Tran for their assistance in the recruitment of participants. N.D.N. is supported by a grant from the AMBeR alliance. T.V.N. is supported by a fellowship from the National Health and Medical Research Council. The Rancho Bernardo Study was funded by the National Institutes of Health/National Institute on Aging (grants AG07181 and AG028507) and the National Institute of Diabetes and Digestive and Kidney Diseases (grant DK31801). Study concept and design: L.T.H.-P., T.V.N., E.B.-C., N.D.N.; acquisition of data: L.T.H.-P., T.Q.V., E.B.-C.; analysis and interpretation of data: L.T.H.-P., T.V.N., N.D.N.; drafting the manuscript: L.T.H.-P., T.V.N., E.B.-C.; statistical expertise: N.D.N., T.V.N.; critical revision of the manuscript: L.T.H.-P., T.V.N., E.B.-C., N.D.N. There was no funding for this study.

DISCLOSURE

[Q6] T.V.N. received honorarium for speaking and providing consultant services to MSD Vietnam Ltd, Sanofi-Aventis, Novartis, and Roche. T.V.N. is supported by a senior research fellowship from the Australian National Health and Medical Research Council. E.B.-C. was a paid external investigator for the raloxifene MORE and RUTH studies by Lilly Research Laboratories. N.D.N. is supported by a grant from the AMBeR (Australian Medical Bioinformatics [Q7] Resource). Other authors declared no conflict of interest.

REFERENCES

1. Haslam DW, James WP. Obesity. *Lancet* 2005;366:1197–1209.
2. WHO. Obesity: preventing and managing the global epidemic. WHO Technical Report Series no. 894. Geneva, 2000.
3. Bozkirli E, Ertorer ME, Bakiner O, Tutuncu NB, Demirag NG. The validity of the World Health Organisation's obesity body mass index criteria in a Turkish population: a hospital-based study. *Asia Pac J Clin Nutr* 2007;16:443–447.
4. De Lorenzo A, Deurenberg P, Pietrantuono M *et al*. How fat is obese? *Acta Diabetol* 2003;40 Suppl 1:S254–S257.
5. Goh VH, Tain CF, Tong TY, Mok HP, Wong MT. Are BMI and other anthropometric measures appropriate as indices for obesity? A study in an Asian population. *J Lipid Res* 2004;45:1892–1898.
6. Romero-Corral A, Somers VK, Sierra-Johnson J *et al*. Accuracy of body mass index in diagnosing obesity in the adult general population. *Int J Obes (Lond)* 2008;32:959–966.
7. Yajnik CS, Yudkin JS. The Y-Y paradox. *Lancet* 2004;363:163.
8. Zhou BF; Cooperative Meta-Analysis Group of the Working Group on Obesity in China. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults--study on optimal cut-off points of body mass index and waist circumference in Chinese adults. *Biomed Environ Sci* 2002;15:83–96.
9. Deurenberg P, Yap M, van Staveren WA. Body mass index and percent body fat: a meta analysis among different ethnic groups. *Int J Obes Relat Metab Disord* 1998;22:1164–1171.
10. Kanazawa M, Yoshiike N, Osaka T *et al*. Criteria and classification of obesity in Japan and Asia-Oceania. *World Rev Nutr Diet* 2005;94:1–12.
11. Deurenberg-Yap M, Schmidt G, van Staveren WA, Deurenberg P. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. *Int J Obes Relat Metab Disord* 2000;24:1011–1017.
12. Wang J, Thornton JC, Russell M *et al*. Asians have lower body mass index (BMI) but higher percent body fat than do whites: comparisons of anthropometric measurements. *Am J Clin Nutr* 1994;60:23–28.
13. Ho-Pham LT, Nguyen PL, Le TT *et al*. Veganism, bone mineral density, and body composition: a study in Buddhist nuns. *Osteoporos Int* 2009; e-pub ahead of print 7 April 2009.
14. Edelstein SL, Barrett-Connor E. Relation between body size and bone mineral density in elderly men and women. *Am J Epidemiol* 1993;138: 160–169.
15. Bergstralh E, Kosanke J. Computerized matching of cases and controls. Technical Report no. 56. Mayo Clinic, Division of Biomedical Statistics and Informatics: Rochester, MN, 1995.
16. R Development Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing: Vienna, Austria, 2008.
17. Gurrici S, Hartriyanti Y, Hautvast JG, Deurenberg P. Relationship between body fat and body mass index: differences between Indonesians and Dutch Caucasians. *Eur J Clin Nutr* 1998;52:779–783.
18. Deurenberg P, Ge K, Hautvast J, Wang J. Body mass index as predictor of body fat: comparison between Chinese and Dutch adult subjects. *Asia Pacific J Clin Nutr* 1997;6:102–105.
19. Cole TJ, Fewtrell MS, Prentice A. The fallacy of using percentage body fat as a measure of adiposity. *Am J Clin Nutr* 2008;87:1959; author reply 1959–1959; author reply 1960.
20. Allison DB, Paultre F, Goran MI, Poehlman ET, Heymsfield SB. Statistical considerations regarding the use of ratios to adjust data. *Int J Obes Relat Metab Disord* 1995;19:644–652.
21. Norgan NG. Population differences in body composition in relation to the body mass index. *Eur J Clin Nutr* 1994;48(Suppl 3):S10–S25; discussion S26–S27.
22. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004;363:157–163.
23. He M, Tan KC, Li ET, Kung AW. Body fat determination by dual energy X-ray absorptiometry and its relation to body mass index and waist circumference in Hong Kong Chinese. *Int J Obes Relat Metab Disord* 2001;25:748–752.
24. Stevens J. Ethnic-specific revisions of body mass index cutoffs to define overweight and obesity in Asians are not warranted. *Int J Obes Relat Metab Disord* 2003;27:1297–1299.
25. Klein S, Burke LE, Bray GA *et al*.; American Heart Association Council on Nutrition, Physical Activity, and Metabolism. Clinical implications of obesity with specific focus on cardiovascular disease: a statement for professionals from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism: endorsed by the American College of Cardiology Foundation. *Circulation* 2004;110:2952–2967.
26. WHO. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Consultation. WHO Technical Report Series, pp 854, 1995.
27. Stevens J, Nowicki EM. Body mass index and mortality in asian populations: implications for obesity cut-points. *Nutr Rev* 2003;61:104–107.
28. Gu D, He J, Duan X *et al*. Body weight and mortality among men and women in China. *JAMA* 2006;295:776–783.
29. Schoeller DA, Tylavsky FA, Baer DJ *et al*. QDR 4500A dual-energy X-ray absorptiometer underestimates fat mass in comparison with criterion methods in adults. *Am J Clin Nutr* 2005;81:1018–1025.