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ORIGINAL CONTRIBUTION

Waist circumference and the risk of hypertension and prediabetes among Filipino women

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Abstract
Objectives To examine waist circumference as a risk factor for having hypertension only, impaired fasting glucose only, or both hypertension and impaired fasting glucose, and assess whether the associations vary according to overweight status. Furthermore, optimal cut-offs for waist circumference in overweight women and non-overweight women were explored.
Data and methods Data from 1,871 women aged 35–68 years in the 2005 Cebu Longitudinal Health and Nutrition Survey were used. Multinomial logistic regressions were used to model how waist circumference influenced the likelihood of having the three illness categories compared to having neither condition. Waist circumference cut-offs were explored using receiver operating characteristic analysis.
Results Adjusted for age and other confounders, each cm increase in waist circumference increased the odds of hypertension by 5 % for non-overweight women and 3 % for overweight women; impaired fasting glucose by 9 and 3 % for non-overweight and overweight women, respectively; and hypertension and impaired fasting glucose by 17 % among non-overweight versus 9 % for overweight women. Waist circumference cut-offs for non-overweight women were lower than overweight women.
Conclusion Waist circumference was significantly associated with impaired fasting glucose and both hypertension and impaired fasting glucose, and the associations vary by overweight status.

Keywords Waist circumference · Overweight · Hypertension · Prediabetes · Filipino women

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Introduction

In the past decades, many developing countries experienced a major increase in the number and proportion of middle-aged and elderly persons as a result of declining fertility and mortality together with significant improvement in health care. The emerging burden of chronic diseases in these age groups represents an important challenge for health care systems as well as concerns about the quality of life for residents of these countries. Using the United Nations' population estimates for 2000 and 2030, the total number of people with diabetes in the world is expected to double as a consequence of population aging and urbanization—171 million versus 366 million [1]. In addition, the estimated total number of adults with hypertension in 2000 was 972 million and in 2025 is predicted to increase to 1.56 billion [2]. In the Philippines, chronic diseases are the main causes of death, with hypertension and diabetes among the top 10 leading causes of mortality [3]. According to the 2008 Philippine National Nutrition Survey (NNS), the overall adult prevalence of hypertension (systolic blood pressure $\geq$140 mmHg or diastolic $\geq$90 mmHg) is 25.3 % and has significantly increased from its 2003 level of 22.5 [4]. The NNS also found rising levels of high fasting blood glucose (FBG >6.9 mmol/L or >125 mg/dL) between 2003 and 2008 (3.4–4.8 %). Within two decades, mortality rates from both illnesses steeply increased.

Hypertension and hyperglycemia often occur together, and it is well known that excess body fat increases the risk of having these conditions [5, 6]. Thus, concern for increasing prevalence of these illnesses is heightened given that 23.2 % of the world's adult population was overweight and 9.8 % was obese in 2005 [7]. About 27 % of Filipinos were overweight/obese—with body mass index (BMI) $\geq$25 kg/m^2) in 2008 [4].

Abdominal obesity is associated with increased risk of having hypertension and Type 2 diabetes. Abdominal fat is either visceral (surrounding the abdominal organs) or subcutaneous (lying between the skin and the abdominal wall). Visceral fat has been linked to metabolic disturbances and is associated with an increased risk of developing heart disease and Type 2 diabetes [8–10]. It is also associated with high total cholesterol levels, which, in turn, increase the risk of heart attacks and strokes [11]. While waist circumference does not differentiate visceral from subcutaneous fat, in large-scale population-based studies, it is a simple and valid way to assess abdominal fat. Waist circumference is believed to be a much more accurate measure of future health risk and is even a stronger predictor of cardiovascular diseases than BMI alone [12, 13]. Several studies have shown that a large waist circumference increases risk of diabetes even when BMI is in the normal range [6, 14].

It has been reported in many studies that there is direct relation between hypertension and diabetes because they share a common set of risk factors and share certain physiological traits—that is, the effects caused by each disease tend to make the other disease more likely to occur [15]. Overall, when averaged across diabetes type and age range, about 35 % of all people with diabetes have high blood pressure [15]. However, one may suffer hypertension without having diabetes or may be diabetic and not hypertensive. Measure of central obesity may be more strongly associated with cardiovascular risks, but there has been no systematic attempt to compare the strength and nature of the associations between this measure and the independence and coexistence of these risks.

The applicability of the WHO cut-off points associated with increased disease risk ($\geq$102 cm for men and $\geq$88 cm for women) has been challenged for other populations or ethnicities [16, 17]. A study of about 3,000 adults in Iran found that the waist circumference cut-off yielding maximum sensitivity plus specificity for predicting the presence of two or more cardiovascular risk factors was 91.5 cm in men and 85.5 cm in women [18]. The differences in optimal cut-offs may reflect differences in the prevalence of risk factors in the populations [19] or different biological associations. While these studies explored optimal waist circumference cutpoints with regard to race, ethnicity, gender, or age, waist circumference cut-offs may vary by overweight status and by cardiovascular-related diseases as well. In developing countries like the Philippines where the burden of cardiovascular disease has accelerated in the last three decades, studies are needed to investigate modifiable risk factors associated with cardiovascular diseases.

The primary aim of this study is to examine how WC and OW independently and synergistically relate to having hypertension (HTN) only, impaired fasting glucose (IFG) or prediabetes only, and both hypertension and impaired fasting glucose (HTN–IFG). Since cut-offs to define high WC and OW status are widely used for the study of disease risk, a secondary aim is to evaluate the predictive properties of different WC cut-offs for these disease outcomes. If associations of high WC with disease outcomes are different in OW and non-OW women, this would suggest that different WC cut-offs are needed according to weight status. With the current strong focus on BMI, non-OW women may not be getting sufficient attention for screening.

Data and methods

Sample

Our study site is located in Metropolitan Cebu, the main urban center of Cebu province in the Philippines. Among the 80 provinces of the Philippines, Cebu ranks fifth in terms of population size [20]. We use data from the community-based Cebu Longitudinal Health and Nutrition Survey (CLHNS). Details of the CLHNS have been published elsewhere [21]. Briefly, in 1983, all pregnant women from 33 randomly selected urban and rural communities of Metro Cebu were asked to participate in the study. Those who gave birth between May 1, 1983 and April 30, 1984 were included in the sample. There were 3,327 pregnant women enrolled and their ages ranged from 15 to 45 years. Subsequent follow-up surveys were conducted bimonthly for 2 years after giving birth and then in 1991, 1994, 1998, 2002, and 2005.

The current study used the CLHNS cross-sectional data from the 2005 survey only. This was the first survey year to add collection of biomarkers with the purpose of assessing cardiovascular disease risk factors.

The 2005 survey included 2,018 women, ages 35–68 years. Compared with the original sample of women in 1983, these women were less educated, of higher parity, resided in rural communities, and from poorer households. Of the 2,018 women, 122 had no blood samples, 12 were pregnant, 5 did not fast overnight, and 8 had missing data on other covariates and were thus excluded from the analytic sample, leaving a final sample of 1,871. Written informed consent to participate in the study was obtained from the sample women, and all protocols were reviewed and approved by the University of North Carolina at Chapel Hill Institutional Review Board.

Outcome variable

Licensed medical technologists drew venous blood after an 8-h overnight fast. Fasting venous whole blood samples were used to analyze glucose using the 'One Touch' (Johnson & Johnson Ltd) glucometer. To approximate plasma glucose, a correction factor of 0.97 mmol/L (17.5 mg/dL) was subtracted from the venous blood glucose values [22]. IFG is defined as having glucose values greater than 6.1 mmol/L (110 mg/dL—based on 1999 WHO Diabetes criteria) or taking anti-diabetic medications.

Blood pressure (BP) was measured in triplicate after at least 10-min seated rest using mercury sphygmomanometers. The average of the three measurements was used in the analyses. BP was measured in the women's left arm, and the first and fifth Korotkoff sounds were used to indicate systolic and diastolic BP, respectively. HTN was defined as systolic BP $\geq$140 mmHg or diastolic BP $\geq$90 mmHg, or taking anti-hypertensive drugs. The outcome variable was categorized into: (1) without HTN or IFG, (2) with HTN only, (3) with IFG only, and (4) with both HTN–IFG.

Exposure variables

Three WC measurements were taken (to the nearest 0.1 cm), placing a plastic tape about two inches above the navel, after normal exhalation. The average of the three measurements was used as a continuous variable. WC in this study was treated alternately as continuous variable and a categorical variable represented using different cut-offs. Height (cm) and weight (kg) were measured using a portable stadiometer and scale, respectively, using standard techniques. OW was defined as a BMI $\geq$25 kg/m^2.

Covariates

Individual, lifestyle, household, and community factors taken into account as potential confounding variables include the following: women's age, education, occupational physical activity, smoking and drinking status, diet (sodium, total calories, and fat intake) and indices of household hygiene, assets, and urbanicity.

The relationship of age to HTN and IFG was not linear; therefore, we defined groups representing: 34–45, 46–54, and 55 years and older. Educational level of women was categorized into (1) with elementary, (2) with high school, and (3) with college education. We assessed occupational physical activity based on the energy expenditure associated with the type of job reported by each woman. Each job was categorized according to the level of physical demand, and energy expenditure values were assigned for specific occupations common among Filipino women [23]. This information was supplemented with data from the Compendium of Physical Activity [24]. A categorical variable represented the activity level (sedentary, light, moderate, heavy) of the woman's occupation, in which a higher category indicated a more demanding job. Women who were not working for pay represented a separate category. Smoking and drinking status were dichotomous variables: currently or not currently engaging in these activities. Diet was assessed using a two 24-h recalls, and nutrient values were derived from the Philippines Food Composition Table [4]. Dietary fat intake was represented as percent calories from fat averaged from the 2 days of recall. A separate questionnaire on use of table salt and high sodium condiments supplemented the dietary recalls. High sodium intake was defined as intake of at least 4,600 mg per day (i.e., 200 % above the recommended daily intake of 2,300 mg).

The household hygiene index was a composite of the type of toilet facility used, amount of feces in the surrounding area, the method of garbage disposal, and cleanliness of the area where the food was kept. Household wealth was represented as asset index that includes the type of lighting used, ownership of house, the type of housing material, and ownership of selected assets including television, air conditioner, tape recorder, refrigerator, or motor vehicle. The urbanicity index was a measure of community's communication, education (school types), transportation, health services, markets, population size, and population density [25]. Higher scores in the three indices denote a more sanitary environment, better household economic status, and a more urbanized community.

Statistical methods

Descriptive statistics included percentage distributions for categorical variables and means for continuous variables. *T* tests were used to compare means and chi-square statistics for proportions. Pairwise correlation of the exposure variable and covariates was performed to determine collinearity. Multinomial logistic regressions were used to model how WC influenced the likelihood of HTN only, IFG only, or both HTN–IFG compared to having neither condition. We compared models with and without a WC-OW status interaction term using a likelihood ratio test to assess whether the association between WC and the outcome differed according to OW status. Likelihood ratio tests (alpha set at 0.10) showed that the estimated effects of WC varied according to women's weight status (*P* values for HTN only, IFG only, and HTN–IFG were 0.33, 0.03, and 0.04, respectively). Thus, analyses were stratified by OW status.

Women's education, smoking and drinking status, asset and hygiene indices were dropped in the final model because they did not meaningfully (>10 %) change the effect estimates of the main exposure variable of interest.

Optimal WC cut-offs to predict HTN and IFG were explored using receiver operating characteristic (ROC) analysis [13, 26, 27] stratified by OW status. To obtain the best cut-off from the ROC curve, that is, to discriminate the disease with non-disease subjects, we chose the Youden method. The Youden index identified the point on the ROC curve which is farthest from the line of equality, calculated as the maximum of sensitivity + specificity [19, 28]. Stata version 10.0 was used for the analyses (StataCorp. 2007. *Stata Statistical Software: Release 10*. College Station, TX: StataCorp LP.). We then compared how empirically defined optimal cutpoints and standard cutpoints related to the disease outcomes using multinomial logistic regressions

Results

Profile of sample women

Women ranged in age from 35 to 68 years, with nearly half between 46 and 54 years (see Table 1). OW women were more likely to be in the younger age group and to have attained at least a high school education. They consumed higher amounts of sodium, carbohydrate, and fat in a day, owned more assets, and resided in more urban and sanitary communities. Non-OW women, on the other hand, were more likely to engage in jobs requiring heavy physical exertion and to smoke.

As expected, OW women were more likely to have cardiovascular-related diseases (Fig. 1). Compared to non-OW, a greater percentage of OW women had HTN, IFG, or both HTN–IFG. HTN–IFG prevalence was nearly 4 times higher among OW women than among non-OW women. Although the majority of non-OW women did not suffer from HTN or IFG, it is noteworthy that about 1 in 4 of them had at least one disease. Conversely, almost half of OW women have HTN, IFG, or both. Non-OW women with high WC (≥88 cm) had a higher prevalence of cardiovascular-related diseases than OW women with high WC.

Multinomial logistic regression

Controlling for age, diet, urbanicity, and occupational physical activity, we found that WC was significantly associated with a higher likelihood of having both HTN and IFG or IFG only (Table 2, Model 1). The association between WC and HTN did not differ by OW status, but the associations between WC and IFG, and WC and HTN–IFG were modified by OW status, with relatively stronger effects among non-OW women. For each centimeter increase in WC, the odds of having both HTN–IFG were substantially higher than having either condition alone, especially for non-OW women. For non-OW women, a 1 cm increase in WC was associated with 17 % increase in the odds of having both HTN–IFG than having isolated HTN (5 %) or IFG (9 %).

Table 1 Profile of sample women in 2005 (n = 1,871)

Characteristics	Non-overweight (n = 1,081)	Overweight (n = 790)	P value
WC, mean (SD)			
Without HTN or IFG	73.6 (7.2)	88.7 (7.5)	0.000
HTN only	75.9 (7.2)	90.8 (8.5)	
IFG only	78.1 (7.5)	90.7 (7.4)	
Both HTN–IFG	82.6 (8.5)	95.0 (8.0)	
All women	74.6 (7.5)	90.0 (8.0)	
BMI (kg/m^2), mean (SD)			
Without HTN or IFG	21.2 (2.6)	28.1 (2.6)	0.000
HTN only	21.8 (2.4)	28.6 (3.1)	
IFG only	22.0 (2.1)	28.4 (3.1)	
Both HTN–IFG	23.0 (2.1)	29.3 (3.2)	
All women	21.4 (2.5)	28.4 (2.9)	
Age group (%)			
35–45 years old	36.6	44.1	0.000
46–54 years old	45.0	44.0	
55 years old and over	18.4	11.9	
Educational level (%)			
With elementary	62.8	53.8	0.000
With high school	26.5	30.8	
With college	10.7	15.4	
Occupational physical activity (%)			
Not working	21.3	18.9	0.000
Sedentary	6.1	5.8	
Light	43.2	56.0	
Moderate	20.5	14.0	
Heavy	8.9	5.3	
Current smokers	17.7	11.0	0.000
Current drinkers	38.0	38.1	0.972
Sodium intake (%)			
High ≥4,600 mg per day	13. 8	17.6	0.024
Total calories intake (g), mean (SD)	1,061.0 (475.1)	1,245.9 (513.6)	0.018
% Fat intake, mean (SD)	13.8 (10.3)	16.6 (11.1)	0.016
Hygiene index, mean (SD)	5.8 (1.7)	6.3 (1.6)	0.043
Asset index, mean (SD)	4.8 (1.9)	5.7 (1.8)	0.045
Urbanicity index, mean (SD)	38.7 (14.7)	42.4 (11.9)	0.000

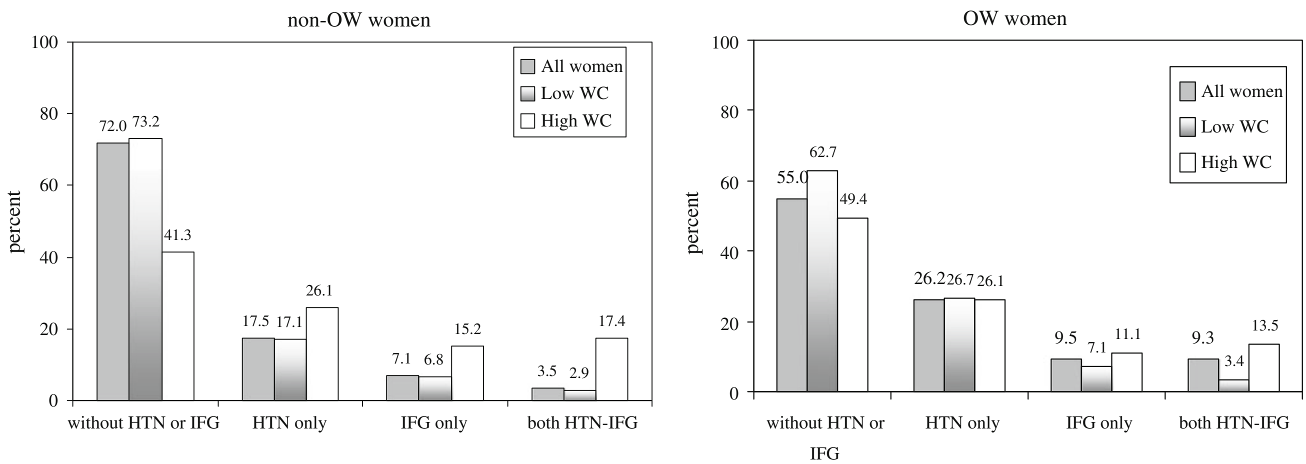

Fig. 1 Percent distribution of women by cardiovascular-related diseases and waist circumference

In addition, we ran models using WC cut-offs of 88 and 75 cm (Table 2, Models 2 and 3). Comparing different WC cut-offs, for the three categories of illness, the odds ratios using lower cutpoint in non-OW women (e.g., 75 cm) were higher than the odds ratios using standard 88 cm cutpoint in OW women. In Model 3, no odds ratio estimates were calculated for OW women since very few OW women have WC <75 cm.

Receiver operating characteristic (ROC) analysis and Youden index

Best WC cut-off values as determined by the Youden index are shown in Table 3. Results suggested lower optimal WC cut-offs for non-OW women than OW women. For HTN, a WC of 76 cm was optimal for non-OW women, while 83 cm was optimal for OW women. For IFG, the optimal WC's were 75 and 88 cm for non-OW and OW women, respectively. The positive predictive values were higher than the observed prevalence of HTN and IFG.

Furthermore, adjusted predicted probabilities setting age at its mean value (results not shown in tables) showed that at higher WC, the probability of developing HTN, IFG, or both illnesses was higher for non-OW women than OW women. Thus, WC is a strong predictor of these cardiovascular-related illnesses independent of age.

Summary and discussion

As shown in many other studies, WC was significantly associated with having HTN and/or IFG in this sample of Filipino women. However, in addition, we found that the associations of WC with IFG and HTN–IFG were modified by OW status, with relatively stronger effects among non-OW women. Consistent with this finding is that the computed optimal cut-off (based on Youden index) WC measurement for predicting IFG and HTN–IFG in non-OW women for this study is lower compared with OW women. Furthermore, our study supported the findings that WC and IFG are significantly associated and the risk of the disease increased with increasing levels of central obesity and holds true for non-OW women [29].

The study presented results by OW status and illness categories, that is, HTN only, IFG only, both HTN–IFG, not lumping together cardiovascular illnesses as what other studies have conducted. The results revealed that the odds of developing cardiovascular-related diseases vary by OW status and by independent occurrence of the disease. This is an important contribution as most of the studies focused on the coexistence of these morbidities. Furthermore, some studies focused on cut-off points for WC or BMI by age and gender [19, 30] and by race-ethnicity groups [31]. As far as studies in the developing countries are concerned, no other study linked WC as a risk factor for the three categories of illnesses according to OW status of the subjects and explored different cut-off points for WC. These findings have important public health significance, particularly in defining levels of WC that represent increased chronic disease risk—that the association between WC and cardiovascular-related diseases varies according to OW status and that optimal cut-offs for WC differ for each categorized illnesses.

As mentioned earlier, some studies have shown that WC cut-offs for men differ from women in predicting presence of two or more cardiovascular risk factors. Although it would be of interest if males are also included in this study, our analysis is limited to females only and at certain age range since our data were taken from a longitudinal survey with mothers only as samples.

The exposure and outcome variables of our study were measured at one point in time making it difficult to

Table 2 Results from multinomial logistic regressions for cardiovascular-related diseases for all women and by OW status, $n = 1{,}871$

CVD-related diseases[a]	Model 1 (per cm increase in WC)			Model 2 (WC cutpoint of 88 cm)			Model 3 (WC cutpoint of 75 cm)[c]	
	RRR[b] (95 % CI)			RRR[b] (95 % CI)			RRR[b] (95 % CI)	
	All women	Non-OW women	OW women	All women	Non-OW women	OW women	All women	Non-OW women
HTN only	1.05 (1.04–1.06)	1.05 (1.03–1.08)	1.03 (1.01–1.06)	2.04 (1.57–2.64)	2.49 (1.16–5.36)	1.18 (0.84–1.66)	2.37 (1.79–3.13)	1.96 (1.40–2.75)
IFG only	1.05 (1.03–1.07)	1.09 (1.06–1.13)	1.03 (1.01–1.06)	2.34 (1.63–3.37)	3.96 (1.57–9.98)	1.79 (1.05–3.06)	3.20 (2.00–5.12)	3.18 (1.89–5.36)
Both HTN–IFG	1.11 (1.09–1.13)	1.17 (1.11–1.22)	1.09 (1.06–1.13)	6.52 (4.26–9.98)	7.00 (2.70–8.20)	4.52 (2.30–8.89)	7.76 (3.70–16.30)	4.71 (2.09–10.67)

Adjusted for age, diet (fat, total calories, and sodium intake), urbanicity index, and physical strain

[a] Reference: without HTN or IFG

[b] RRR refers to the relative risk ratio derived from the multinomial logit (e^b), that is, the risk of the outcome relative to the base outcome

[c] In Model 3, the odds ratios for OW women were not estimated since very few OW women have WC <75 cm

Table 3 Area under the curve (AUC), optimal WC cut-off values, sensitivities and specificities, predictive values by OW status, and CVD-related diseases

OW status and CVD-related diseases	n	AUC		Optimal WC cut-off				
		Unadjusted	Adjusted	Cut-offs (cm) (Youden index)	Sensitivity	Specificity	Positive predictive values	Negative predictive values
Non-overweight								
HTN only	187	0.59	0.69	76	55.08	61.14	25.56	84.89
IFG only	82	0.66	0.67	75	71.95	54.02	14.25	94.77
Overweight								
HTN only	197	0.58	0.62	83	89.34	23.29	35.06	82.50
IFG only	83	0.58	0.62	88	71.08	45.88	20.41	89.04

Adjusted for age, diet (fat, total calories, and sodium intake), urbanicity index, and physical strain distinguish which comes first, whether abdominal obesity preceded or occurred after the women experienced the three categories of illnesses. While the cross-sectional nature of the study limits causal inference, and the sample is limited to women aged 35–68 years, this study supports a WC cut-off for Asian women <88 cm [16–18, 30, 32, 33]. In our sample, it appears that the 88 cm cut-off for WC measurement is appropriate only for Filipino women who are OW. The calculated positive predictive values of the cut-offs showed higher values compared with the prevalence of the three categorized illnesses that may indicate that these cut-offs improve prediction. With our models that alternately used WC cutpoints of 88 versus 75 cm, for non-OW women, even with lower cutpoint of 75 cm instead of 88 cm, the odds ratios were larger than those for OW women at 88 cm. This is a key justification for using a lower WC cut-off to define risk in women who are not overweight and who might be otherwise neglected in screening. Since we are aiming for the prevention of cardiovascular-related diseases, 88 cm is already too high especially for non-OW women in whom the relative effect of an increase in WC is higher than among OW women. Therefore, non-OW women should not assume that they are at low risk of cardiovascular diseases.

The prevalence rate of IFG and high FBS in the Philippines is 2.7 and 4.8 %, respectively [4]. Although prevalence rate of diabetes in the Philippines is relatively low over time compared to other illnesses, an increasing trend of the illness has been observed for the whole population from 2003 to 2008—3.4–4.8 % [4]. In addition, the same increasing trend was observed for hypertension but at relatively higher levels for the same time period and increasing from 22.5 to 25.3 % [4]. Like other developing countries, prevalence rates for hypertension and diabetes in the Philippines now surpass those of most industrialized countries [34, 35]. Our study is very timely and may be used to inform prevention efforts to limit increase in the prevalence of these illnesses in the future. Known risk factors for HTN and IFG include being overweight/obese and having high WC. The computed optimal cut-off (based on Youden index) WC measurement for non-OW women for this study is lower compared than OW women; therefore, the former should not assume that they are not at risk even if they are not OW. Program planners should stress prevention of abdominal obesity, in addition to weight reduction efforts, to decrease the risk of developing cardiovascular-related diseases especially IFG to the whole population regardless of their OW status. The results of our study may not represent the whole Philippine population, so we recommend similar analysis on a nationally representative data for policy makers and stakeholders to better address the increasing prevalence of these cardiovascular-related diseases.

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Conflict of interest The authors declared no conflict of interest.

References

1. Wild S, Roglic G, Green A, Sicree R, King H (2004) Global prevalence of diabetes—estimates for the year 2000 and projections for 2030. Diabetes Care 27(5):1047–1053
2. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J (2005) Global burden of hypertension: analysis of worldwide data. Lancet 365(9455):217–223
3. World Health Organization, Mortality Country Fact Sheet. 2006, World Health Organization
4. Food and Nutrition Research Institute of the Department of Science and Technology, 7th National Nutrition Survey: Philippines (2008): Initial Results CLINICAL AND HEALTH SURVEY the Food and Nutrition Research Institute of the Department of Science and Technology (FNRI-DOST) Food Composition Tables: Recommended for Use in the Philippines: Handbook The Philippine Food Composition Tables: Food and Nutrition Research Institute, 2008
5. Lee D, Sui X, Church T, Lee I-M, Blair S (2009) Associations of cardiorespiratory fitness and obesity with risks of impaired fasting glucose and type 2 diabetes in men. Diabetes Care 32: 257–262
6. Janssen I, Katzmarzyk PT, Ross R (2004) Waist circumference and not body mass index explains obesity related health risk. Am J Clin Nutr 79:379–384
7. Yang KT, Chen CS, Reynolds K, He J (2008) Global burden of obesity in 2005 and projections to 2030. Int J Obes 32(9): 1431–1437
8. Racette SB, Evans EM, Weiss EP, Hagberg JM, Holloszy JO (2006) Abdominal adiposity is a stronger predictor of insulin resistance than fitness among 50–95 year olds. Diabetes Care 29(3):673–678
9. Koh-Banerjee P, Wang Y, Hu FB, Spiegelman D, Willett WC, Rimm EB (2004) Changes in body weight and body fat distribution as risk factors for clinical diabetes in US men. Am J Epidemiol 159:1150–1159
10. Wahrenberg H, Hertel K, Leijonhufvud B-M, Persson L-G, Toft E, Arner P (2006) Use of waist circumference to predict insulin resistance: retrospective study. BMJ 330:1963–1964
11. Pitanga FJG, Lessa I (2005) Anthropometric indexes of obesity as an instrument of screening for high coronary risk in adults in the city of Salvador—Bahia. Arquivos Brasileiros Cardiol 85:1–5
12. Haffner SM, Despres J-P, Balkau B et al. (2006) Waist circumference and body mass index are both independently associated with cardiovascular disease: the international day for the evaluation of abdominal obesity (IDEA) survey. J Am Coll Cardiol 47(4 suppl A)(358A):842–846
13. Zhu SK, Wang ZM, Heshka S, Heo M et al (2002) Waist circumference and obesity-associated risk factors among whites in the third National Health and Nutrition Examination Survey: clinical action thresholds. Am J Clin Nutr 76:743–749
14. Vikram NK, Pandey RM, Misra A, Sharma R, Devi JR, Khanna N (2003) Non-obese (body mass index <25 kg/m^2) Asian Indians with normal waist circumference have high cardiovascular risk. Int J Appl Basic Nutr Sci 19(6):503–509
15. http://highbloodpressure.about.com. Accessed on 27 May 2011
16. Misra A, Vikram NK, Gupta R, Pandey RM, Wasir JS, Gupta VP (2006) Waist circumference cutoff points and action levels for

Asian Indians for identification of abdominal obesity. Int J Obes 30:106–111
17. Kim JA, Choi CJ, Yum KS (2006) Cut-off values of visceral fat area and waist circumference: diagnostic criteria for abdominal obesity in a Korean population. J Korean Med Sci 21:1048–1053
18. Esteghamati A, Ashraf H, Rashidi A, Meysamie A (2008) Waist circumference cut-off points for the diagnosis of metabolic syndrome in Iranian adults. Diabetes Res Clin Pract 82(1):104–107
19. Cameron AJ, Sicree RA, Zimmer PZ et al (2010) Cut-points for waist circumference in Europids and South Asians. Obesity 18(10):2039–2046
20. http://www.census.gov.ph/data/census2007/index.html. Accessed 30 Aug 2011
21. Adair LS, Popkin BM, Akin JS, Guilkey DK, Gultiano S, Borja J, Perez L, Kuzawa CW, McDade T, Hindin MJ (2011) Cohort profile: the Cebu longitudinal health and nutrition survey. Int J Epidemiol 40:619–625
22. Kumar CPTG, Sng CPTBL, Kumar COLS (2004) Correlation of capillary and venous blood glucometry with laboratory determination. Prehosp Emerg Care 8:378–383
23. Tuazon MA, van Raaij JM, Hautvast JG, Barba CV (1987) Energy requirements of pregnancy in the Philippines. Lancet 2:1129–1131
24. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, O'brien WL, Bassett DR Jr, Schmitz KH, Emplaincourt PO, Jacobs DR Jr, Leon AS (2000) Compendium of physical activities: an update of activity codes and MET intensities. MEDICINE & SCIENCE IN SPORTS & EXERCISE, Copyright @ 2000 by the International Life Sciences Institute, pp S498–S516
25. Dahly D, Adair LS (2007) Quantifying the urban environment: a scale measure of urbanicity outperforms the traditional urban-rural dichotomy. Soc Sci Med 64(7):1407–1419
26. Liu A, Hills AP, Hu X, Li Y, Du L, Xu Y, Byrne NM, Ma G (2010) Waist circumference cut-off values for the prediction of cardiovascular risk factors clustering in Chinese school-aged children: a cross-sectional study. BMC Public Health 10(82):1–9
27. Tuan NT, Adair LS, Popkin BM (2008) Optimal cutoff values for overweight: using body mass index to predict incidence of hypertension in 18- to 65-year-old Chinese adults. J Nutr 138: 1377–1382
28. ROCCurve.pdf: http://www.medicalbiostatistics.com, pp 1–9. Accessed 4 March 2011
29. Rosenthal AD, Jin F, Shu X-O, Yang G, Elasy TA, Chow W-H, Ji B-T, Xu H-X, Li Q, Gao Y-T, Zhen W (2004) Body fat distribution and risk of diabetes among Chinese women. Int J Obesity 28:594–599
30. Snehalatha C, Viswanathan V, Ramachandran A (2003) Cutoff values for normal anthropometric variables in Asian Indian adults. Diabetes Care 26:1380–1384
31. Zhu S, Heymsfield SB, Toyoshima H, Wang Z, Pietrobelli A, Heshka S (2005) Race-ethnicity-specific waist circumference cutoffs for identifying cardiovascular risk factors. Am J Clin Nutr 81(2):409–415
32. Zhou B-F, The Cooperative Meta-analysis Group of Working Group on Obesity in China (2002) 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. Asia Pac J Clin Nutr 11(Supplement s8):S685–S693
33. Wildman RP, Gu D, Reynolds K, Duan X, He J (2004) Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults. Am J Clin Nutr 80:1129–1136
34. Cockram CS (2000) The epidemiology of diabetes mellitus in the Asia-Pacific region. HKMJ 6(1):43–52
35. 30Philippines07.pdf *PHILIPPINES COUNTRY HEALTH INFORMATION PROFILES, pp 328–344