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Comparison of body mass index, waist circumference, and waist to height ratio in the prediction of hypertension and diabetes mellitus: Filipino-American women cardiovascular study

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ABSTRACT

The relative ability of three obesity indices to predict hypertension (HTN) and diabetes (DM) and the validity of using Asian-specific thresholds of these indices were examined in Filipino-American women (FAW). Filipino-American women ($n = 382$), 40–65 years of age were screened for hypertension (HTN) and diabetes (DM) in four major US cities. Body mass index (BMI), waist circumference (WC) and waist circumference to height ratio (WHtR) were measured. ROC analyses determined that the three obesity measurements were similar in predicting HTN and DM (AUC: 0.6–0.7). The universal WC threshold of ≥35 in. missed 13% of the hypertensive patients and 12% of the diabetic patients. The Asian WC threshold of ≥31.5 in. increased detection of HTN and DM but with a high rate of false positives. The traditional BMI ≥ 25 kg/m^2 threshold missed 35% of those with hypertension and 24% of those with diabetes. The Asian BMI threshold improved detection but resulted in a high rate of false positives. The suggested WHtR cut-off of ≥0.5 missed only 1% of those with HTN and 0% of those with DM. The three obesity measurements had similar but modest ability to predict HTN and DM in FAW. Using Asian-specific thresholds increased accuracy but with a high rate of false positives. Whether FAW, especially at older ages, should be encouraged to reach these lower thresholds needs further investigation because of the high false positive rates.

1. Introduction

The risk for hypertension (HTN) and diabetes mellitus (DM) in Asian-Americans has been under-estimated and thus prevention and early diagnosis of such chronic diseases has been hampered. (Hsu et al., 2015). The prevalence of HTN and DM varies greatly among Asians subgroups making it necessary to study Asian ethnic groups separately for development of successful prevention, screening and treatment strategies (Holland et al., 2011). Filipino-Americans, the second largest growing Asian-American subgroup, suffer disproportionately from metabolic and cardiovascular disorders with high rates of HTN (Zhao et al., 2015; Ursua et al., 2014), DM (Wang et al., 2011; Nguyen et al., 2015; Huang and Zheng, 2015) and metabolic syndrome (Palaniappan et al., 2011; Ancheta et al., 2012). For example, in a cross-sectional study of 208,985 patients, Filipino-Americans had higher rates of HTN and difficulty attaining adequate HTN control compared to others (Zhao et al., 2015). Additionally, in another cross-sectional sample of 94,423 patients, the risk for stroke and heart disease were significantly higher for Filipino-American women (FAW) compared to other Asian-Americans (Holland et al., 2011), not surprising given FAW's high rates of uncontrolled HTN (Zhao et al., 2015; Ursua et al., 2014). Moreover, DM was more likely in Filipino-Americans despite lower BMI (23–24.9 kg/m^2) compared to non-Hispanic Whites (Jih et al., 2014), and compared to other Asians (Shih et al., 2014). Although it is well established that FAW are at increased risk for both HTN and DM compared with many other groups, the reasons for these disparities are not fully understood.

The increased risk of HTN and DM in FAW may in part result from the prevalence of overweight and obesity in this population (Holland et al., 2011; Ancheta et al., 2014). However, the threshold BMI for determining obesity has not been clearly established for FAW. Current guidelines define BMI thresholds of 25–29.9 kg/m^2 for overweight and 30–34.9 kg/m^2 for obesity in all races (Araneta and Barrett-Connor, 2005)

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but lower thresholds have been proposed for use in Asians (Hsu et al., 2015; Tuan et al., 2008). In support of this premise, Asian-Americans including Filipinos have higher rates of metabolic syndrome at lower BMIs than Caucasians suggesting that BMI ranges should be lower for defining overweight/obesity for Americans of Asian ethnicity (Palaniappan et al., 2011). Although a lower BMI threshold is suggested for FAW, whether this threshold should be used for FAW with an admixed genetic background (Banda et al., 2015) is unclear. Among Southeast Asian countries, the Philippines has a very distinct culture, history, and genetic makeup, which encompasses both Austronesian and European components. Thus, one of our objectives was to evaluate the efficacy of different BMI thresholds for predicting HTN and DM in a cohort of older FAW, who participated in a community-based study.

Another objective of this work was to compare three abdominal obesity indices as predictors of hypertension and DM in FAW. Although BMI has been the gold standard for obesity determination for years, recent work has indicated that waist circumference (WC) and waist to height ratio (WHtR) may be more accurate predictors of health because they measure central obesity (Pischon et al., 2008; Kodama et al., 2012). Filipinas have higher visceral adipose tissue/abdominal obesity at the same BMI compared to other groups. (Araneta and Barrett-Connor, 2005). Thus, waist circumference (WC) and waist to height ratios (WHtR) may have better clinical utility than BMI for predicting disease risk in FAW. Before these central obesity measurement tools can be used in clinical practice, thresholds for determining HTN and DM need to be determined in FAW, because central obesity thresholds may vary as a function of ethnicity. The International Diabetes Federation (IDF) guideline for WC is 31.5 in. in Asians (International Diabetes Foundation, 2006) while the National Cholesterol Education Program Adult Treatment Panel III sets the threshold at 35 in. with no change for Asian ethnicity (JAMA, 2001). Whether lowered thresholds should be applied to FAW needs further study in part for the reasons stated above for BMI. Lastly, WHtR as a predictor of HTN and DM was studied because it may be a better indicator than other measurements (Jayawardana et al., 2013; Ho et al., 2003). Evidence suggests a WHtR value of ≥0.50 predicts DM, HTN, CVD, and dyslipidemia (Ashwell et al., 1996; Park et al., 2009; Aekplakorn et al., 2006) but to the best of our knowledge, differences as a function of ethnicity and race are not known for this measurement.

Based upon the above discussion, a comparison of the three obesity measurements and validation of the use of Asian thresholds of BMI and WC for HTN and DM screening in FAW are needed. This study, was undertaken to compare these three morphometric measurements and to determine optimal thresholds for each as predictors of HTN and DM in middle-aged FAW.

2. Methods

2.1. Study design and subject recruitment

This cross-sectional study was conducted using a cohort of Filipino women ($n = 382$) in four cities of the United States: Jacksonville, FL; Chicago, IL; Tampa, FL; San Francisco, CA between 2010–2013. Participants were 40–65 years old, who had fasted for at least 12 h. Women who had severe arthritis, any autoimmune disorder, a recent cancer diagnosis and/or presented with any infection or severe inflammation were excluded from the study. Institutional Research Board (IRB) approval was obtained prior to conducting the study and informed consent was obtained from each participant. Participants were recruited from places of worship, frequented by FAW. Consent for the study was obtained from the appropriate pastor or parish priest. Community volunteers, actively involved in women's ministry, were in charge of disseminating information regarding the upcoming study. At least two weeks before the scheduled event, information regarding the study regarding the date, day, time, location, study eligibility to include a 12-hour fasting requirement were presented to potential participants, and distributed as flyers and printed in church bulletins. Invitations to participate in the research study were also posted in different public places frequented by FAW.

2.2. Measurements and statistics

Anthropometric measurements were taken while participants were lightly clothed with no shoes. WC was measured to the nearest 0.1 in. using a tension measuring tape at the narrowest point between the iliac crest and the lowest rib when the participant exhaled (NHANES protocol). Height and weight were measured using a standard Tanita scale (WB-3000) with stadiometer. Waist to height ratio was then calculated. BMI was calculated as weight (kg) divided by height squared (m^2). A licensed phlebotomist drew 5 mL of blood via venipuncture from each participant for hemoglobin A1c and serum glucose. All specimens were sent to a CLIA certified laboratory. DM was defined using the American Diabetes Association's classification (American Diabetes Association, 2015), serum fasting blood glucose ≥ 126 mg/dL, hemoglobin A1c ≥ 6.5, or use of an anti-diabetic medication. Blood pressure was obtained using a standard Omron digital HEM-705CP sphygmomanometer on the left or non-dominant arm, after the participant had been seated for 10 min. Measurements were repeated twice with 5 min in between each reading, and an average reading was obtained for better blood pressure accuracy. Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg, or the use of an antihypertensive medication.

A confidential, password-secured Microsoft Excel database was used for data entry and management. Inconsistencies were checked, and the data descriptions were verified. Receiver Operating Curves were generated and analyzed using MedCalc software (https://www.medcalc.org/index.php). Odds ratios comparing the numbers of participants with HTN and DM as a function of BMI, WC and WHtR group were calculated by Fisher's Exact test with Yates continuity correction using *GraphPad InStat* version 3.05 http://www.graphpad.com/scientific-software/instat/. Means ± standard errors were also calculated using this software. Statistical significance was set at $p < 0.01$.

3. Results

3.1. Demographics and obesity measurements

The demographics of the study population ($n = 382$) are presented in Table 1. The mean age of the participants was 53 years with the average duration of residency in the USA > 20 years. The majority of participants were married, had college degrees, insurance and were employed. The mean weight of participants was 137 ± 22 lbs. and mean height was 61 ± 3 in. (Table 2). Most participants were at least 7% shorter than the average US women's height of 5 ft 4 in. (Lin et al., 2002). Analyses showed that 24% of the study subjects met NCEP standards for optimal waist circumference (≤35 in.) and only 4% meet IDF recommendations (≤31 in.). Almost all subjects exceeded the recommended WHtR of <0.5 (94%). The majority (57%) were overweight as defined by BMI ≥ 25 kg/m^2. Both WC and WHtR correlated with BMI (Pearson's correlation coefficient $r = 0.81$ $p < 0.0001$ and 0.83 $p < 0.0001$, respectively). None of the obesity measurements correlated with age (data not shown). Blood pressure and DM measurements are also presented in Table 2. Fifty percent of the study population were identified as hypertensive, with 73% of these subjects controlled by medication. Thirty percent of the study population was classified as diabetic with 45% of these controlled by medication.

3.2. Anthropometric measurements and hypertension

ROC analyses were used to determine the relative ability of the three anthropometric measurements to predict HTN (Fig. 1; Table 3). The areas under the curve (AUC) were 0.63 ± 0.03 (WC), 0.63 ± 0.03

Table 1
Demographic information for the Filipino-American women participants.

Variable	Mean ± SD or % group
Age (years)	53 ± 7
Years in USA	24 ± 13
Age upon arrival in USA (years)	31 ± 12
Income	
<$12,000–$20,000	24%
$21,000–$40,000	25%
$41,000–$69,000	23%
$70,000 and above	28%
Education	
Less than high school	2%
High school diploma	8%
Some college	20%
4 year degree and above	69%
Residency in the U.S.	
Less than 5 years	12%
5–10 years	8%
10–20 years	21%
>20 years	59%
Marital status	
Single	10%
Married	72%
Widow/widower	6%
Divorced/separated	12%
Occupation	
Management	5%
Business, finance and administration	14%
Health occupations	35%
Sales and service	11%
Other	30%

(WHtR) and 0.66 ± 0.03 (BMI). The AUCs of all three measurements were poor (0.6–0.7, http://gim.unmc.edu/dxtests/roc3.htm) indicating that none of these are able to predict HTN without considering other factors. The thresholds estimated by ROC were: WC ≥ 36.5 in., WHtR ≥ 0.60 and BMI ≥ 25.5 kg/m^2 but all of these thresholds had low specificities and sensitivities. Additionally, the specificity and sensitivity of Asian and universal thresholds were determined using the ROC curves. For BMI, the universal threshold of ≥25 kg/m^2 increased sensitivity to 65% but dropped specificity to 60%. Using the WHO Asian BMI threshold of ≥23 kg/m^2, sensitivity increased to 84% with a specificity of 32%. The WC cut-off of ≥35 in. increased sensitivity slightly to 78% with 40% specificity. However, lowering the WC threshold to the Asian threshold of ≥31.5 in., increased specificity to >90% but with a great loss in specificity (<10%). Similarly the WHtR of ≥0.5 when used as the threshold dramatically increased sensitivity to >90% but specificity was below 10%.

To further examine the question of which threshold should be used for HTN assessment, the numbers with and without HTN as a function of threshold were counted and odds ratios comparing the numbers in each group based on the various thresholds were calculated (Table 4). In the case of WC, odds ratios comparing the groups were statistically significant. Approximately, 87% of those subjects classified as hypertensive had WC ≥ 35 in.; thus, 13% of the hypertensive participants would be missed if the threshold was set at the higher level. If the WC threshold was set at the Asian cut-off of ≥31.5 about 2% hypertensives would be missed. However, setting the threshold so low would result in numerous false positives as only 33% of those with a WC of 31.6–34.9 were hypertensive. In the case of BMI, odds ratios were statistically significant. Approximately 70% of the hypertensive group had ≥25 BMI. If the Asian threshold of ≥23 BMI was used, another 15% of the hypertensives would be identified. However, the majority (62%) of the 23.1–24.9 BMI

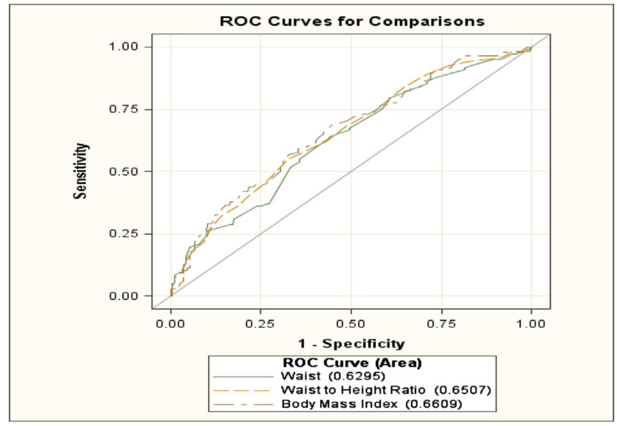

Fig. 1. Receiver Operating Curves: hypertension as a function of body mass index, waist circumference and waist to height ratio.

Table 2
Anthropometric measurements, blood pressure and diabetes mellitus of the Filipino-American woman participants.

Variables	Mean ± SD	% group
Height (inches)	61 ± 3	
Weight (lbs)	137 ± 22	
Waist circumference (inches)	37 ± 4	
% subjects with IDF definition ≤ 31.5 in.		4%
% subject with ATP III ≤ 35 in.		24%
Waist to height ratio	0.62 ± 0.08	
% subjects < 0.5		6%
% subjects > 0.5		94%
Body mass index (kg/m^2)	27 ± 13	
% subjects ≥ 25 kg/m^2 (overweight)		57%
% subjects ≥ 30 kg/m^2 (obese)		17%
Systolic blood pressure (mm Hg)	129 ± 18	
≥140 mm Hg		25%
Diastolic blood pressure (mm Hg)	83 ± 10	
≥90 mm Hg		28%
Hypertensive (elevated BP or medication)		50%
Fasting blood sugar (mg/dL)	100 ± 25	
≥126 mg/dL		8%
Hemoglobin A1C %	6.0 ± 0.9	
≥6.5%		18%
Diabetic (elevated A1C% or medication)		30%

Table 3
Receiver Operating Curve determined threshold levels and traditional threshold values for hypertension and diabetes mellitus as a function of body mass index (BMI), waist circumference and waist circumference to height ratio (WHtR).

	Waist circ.	WHtR	BMI
Hypertension			
Area under curve ± SD	0.63 ± 0.03	0.65 ± 0.2	0.66 ± 0.03
95% CI	0.57–0.68	0.60–0.71	0.60–0.72
Z statistic	4.39	4.74	5.67
Youden index J	0.21	0.23	0.23
ROC cut-off	36.6 (34.5–38)	0.60 (0.57–0.66)	25.5 (23.5–30)
Sensitivity/specify	73%, 50%	65%, 55%	65%, 60%
Published cut-off	35	0.5	25
Sensitivity/specificities	78%, 40%	94%, 6%	68%, 57%
Asian cut-off	31.5		23
Sensitivity/specificities	9%, 6%		84%, 32%
Diabetes			
Area under curve ± SD	0.66 ± 0.04	0.65 ± 0.04	0.68 ± 0.04
95% CI	0.61–0.71	0.61–0.70	0.63–0.73
Z statistic	4.28	4.05	5.15
Youden index J	0.25	0.28	0.35
ROC cut-off	37.1 (36.1–41.2)	0.62(0.57–0.65)	25.5 (22.6–28.2)
Sensitivity/specificities	65%, 63%	73%, 63%	68%, 65%
Published cut-offs	35	0.5	25
Sensitivity/specificities	83%, 34%	95%, 6%	71%, 60%
Asian cut-off	31.5		23
Sensitivity/specificities	97%, 8%		89%, 28%

Table 4
Prevalence of hypertension and diabetes mellitus as a function of waist circumference, body mass index and waist circumference to height ratio categories.

Waist circ. Categories Inches	≤31.5 $N = 15$	31.6–34.9 $N = 67$	Total ≤ 34.9 $N = 81$	≥35 $N = 295$	Odds ratio 95% CI	*p* value
Hypertension % of group	20%	33%	30%	53%	2.84[1] 1.7–4.8	0.0001
% of total hypertensives	2%	13%	15%	85%	2.60[2] 1.49–4.54	0.001
Diabetes % of group	0%	15%	12%	25%	2.37[1] 1.15–4.8	0.01
% of total diabetics	0%	12%	12%	88%	1.90[2] 0.91–3.89	0.11
WHtR categories	≤0.5 $N = 13$	0.51–0.59 $N = 155$	Total < 0.59 $N = 168$	≥0.6 $N = 207$	Odds ratio 95% CI	*p* value
Hypertension % of group	15%	39%	37%	62%	2.83[3] 1.86–4.31	0.0001
% of total hypertensives	1%	31%	32%	68%	2.62[4] 1.71–4.02	0.0001
Diabetes % of group	0%	13%	12%	28%	2.84[3] 1.63–4.97	0.001
% of total diabetics	0%	26%	26%	74%	2.62[4] 1.50–4.60	0.001
BMI categories	≤23 $N = 87$	23.1–24.9 $N = 76$	Total < 24.9 $N = 163$	≥25 $N = 215$	Odds ratio 95% CI	*p* value
Hypertension % of group	32%	38%	35%	62%	3.02[5] 1.97–4.61	0.0001
% of total hypertensives	15%	15%	30%	70%	2.63[6] 1.53–4.50	0.001
Diabetes % of group	7%	18%	12%	29%	2.96[5] 1.71–5.15	0.0001
% of total diabetics	7%	17%	24%	76%	1.836[6] 0.95–3.52	0.07

NOTE: [1]WC ≥ 35 vs <35 in.; [2]WC 31.6–34.9 vs ≤31.5, [3]≥0.6 vs <0.6, [4]0.51–0.59 vs ≤0.5, [5]≥25 vs <25, [6]23.1–24.9 vs ≤23.

group were not hypertensive. Considering WHtR, odds ratios were significant and 31% the hypertensives were in the WHtR 0.51–0.6 group while the majority of hypertensives (69%) had WHtR ≥ 0.6.

3.3. Anthropometric measurements and diabetes

ROC analysis was conducted to investigate the relative ability of the three obesity measurements to predict DM (Fig. 2; Table 3). The areas under the curve (AUC) were 0.66 ± 0.04 (WC), 0.65 ± 0.04 (WtHR) and 0.68 ± 0.04 (BMI); all of these AUCs are considered poor. The thresholds suggested by this analysis were: WC ≥ 37.1 in. (62% sensitivity; 63% specificity), WHtR ≥ 0.61 (69% sensitivity; 59% specificity) and BMI ≥ 26.5 kg/m^2 (60% sensitivity; 75% specificity). Next, the specificity and sensitivity of universal and Asian thresholds were compared using the ROC curves. In the case of BMI, lowering the cut-off to ≥25 kg/m^2 increased sensitivity slightly to 71% but dropped specificity to 60%. Using the WHO Asian BMI threshold of ≥23 kg/m^2, sensitivity increased to 89% with a specificity of 28%. The WC cut-off of ≥35 in. increased sensitivity to 83% with 34% specificity. However, lowering the WC threshold to ≥31.5 in., increased sensitivity to 97% but with a great loss in specificity (8%). Similarly the WHtR of 0.5 when used as the threshold dramatically increased sensitivity to 95% but specificity was below 10%.

To further examine the question of which threshold should be used for DM assessment, we determined the numbers with and without DM as a function of threshold and calculated odds ratios comparing the groups (Table 4). For WC odds ratios were significant. Approximately, 88% of those subjects classified as diabetic had WC ≥ 35 in.; thus, 12% of the diabetics would be missed setting the threshold at the higher level. If the WC threshold was set at ≥31.5 in., no one with DM would be misclassified but there would be numerous false positives as only 12% of those with a WC of 31.6–34.9 were diabetic. Similarly, odds ratios for BMI groups were significant and 76% of the diabetic group had BMI ≥ 25. If the Asian threshold of ≥23 BMI was used, another 17% of the diabetics would be identified, but the rate of false positives is quite high. Considering WHtR, odds ratio was significant and 26% the diabetics were in the WHtR 0.51–0.6 group while the majority of diabetics (74%) had WHtR ≥ 0.6.

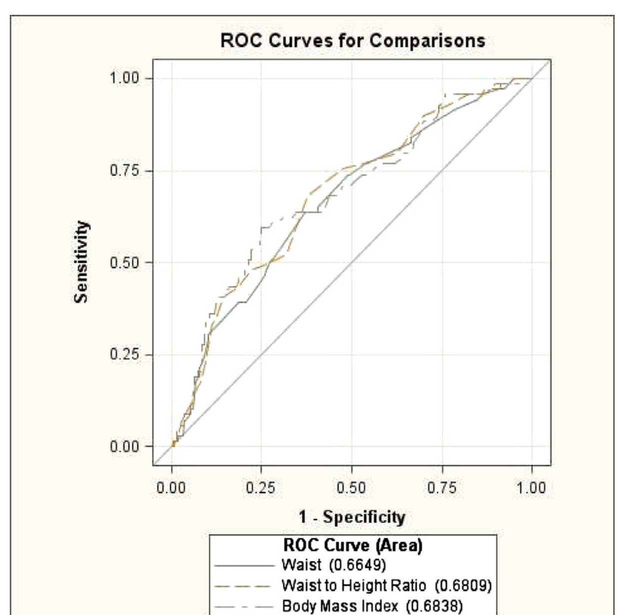

Fig. 2. Receiver Operating Curves: diabetes as a function of body mass index, waist circumference and waist to height ratio.

4. Discussion

A high percentage of our group of Filipino women, who were mostly born in the Philippines but had resided in the USA for a period of time, were overweight using universal standards. Forty percent of the FAW cohort were overweight and 17% were obese as defined by BMI while 76% of the participants had a WC ≥ 35 in. and 96% had a WC ≥ 31.5 in. Almost all subjects were above the recommended the WHtR value of 0.5. Another finding of this study is that BMI, WC, and WHtR had a comparable ability to predict HTN and DM in older FAW, although these predictions were fair at best. Furthermore, our results support the premise that lower thresholds of BMI, WC and WHtR may be appropriate when screening for HTN and DM in FAW to reduce false negatives. But whether FAW, especially at older ages, should be encouraged to reach these lower thresholds needs further investigation.

Waist circumference, waist to height ratio and BMI appear to be useful screening tools for HTN and DM in FAW. Thus, our results do not support the premise that BMI is poorer than waist circumference as a measure of obesity because it does not distinguish fat from muscle which may misestimate a patient's weight status (Willett et al., 1999). Our results are in keeping with the Decoda Study (2008) which reported that BMI and WC equally predicted HTN and DM in Asians of different ethnicities. This group did not use WHtR but reported that waist to hip ratio had a stronger association with diabetes than BMI and WC. In contrast, Ashwell et al. (1996) in a meta-analysis comparing WHtR, WC, and BMI in subjects with different nationalities concluded that WHtR was the best measure of obesity. In another meta-analysis, WHtR was modestly better than BMI for diabetes prediction (Kodama et al., 2012).

To determine obesity measurements' threshold for screening purposes, sensitivity and specificity need to be balanced to provide an inclusive screening measurements with low number of false positives. Many studies have determined BMI thresholds for CVD risk, HTN and DM, although Asians typically have a higher proportion of body fat than Caucasians at the same BMI and waist circumference (Wulan et al., 2010), Asian-specific cut-offs may not be ideal for all Asian-American subgroups (Hsu et al., 2015). Setting threshold values for predicting HTN and DM is difficult because "one size does not fit all". Several studies have validated differences for these anthropometric measurements between South and East Asians. The DISTANCE study suggested a conventional BMI cut point of 25 kg/m^2 as an acceptable threshold to predict DM for South Asians and Southeast Asians (Karter et al., 2013) However, the Women's Health Initiative (Ma et al., 2012), the Seattle Japanese-American Community Diabetes Study (Wander et al., 2013), the multiethnic cohort study from Canada (Chiu et al., 2011), and the Multiethnic Cohort in Hawaii (Maskarinec et al., 2009) support lowering the BMI threshold, especially for East Asians. Araneta et al. (2015) consolidated data from 1663 Asian–Americans participants, ages ≥ 45 years, from population- and community-based studies, and found that limiting screening to BMI ≥ 25 kg/m^2 would miss 36% of Asian Americans with type 2 diabetes. For screening purposes, higher sensitivity is desirable to minimize missing cases, especially if the diagnostic test is relatively simple and suggest that BMI ≥ 23 kg/m^2, sensitivity (84.7%) would miss only ~15% of Asian Americans with diabetes. There is no doubt that the application of the Asian-specific thresholds to our cohort improved HTN and DM detection but with high false positive rates. Indeed, Hsu et al. (2015) states that the lower thresholds should not redefine BMI thresholds for overweight and obesity thresholds in relationship to mortality or morbidity in Asian Americans. Moreover, a recent study did not find an increased risk of total mortality among Asian Americans within the BMI range of 20 to <25 kg/m^2 (Park et al., 2014). Mounting evidence also suggests that not all obese subjects are at increased cardiovascular risk. For example, a cross-sectional study of Koreans demonstrated that metabolic health is more closely associated with the prevalence of cardiovascular disease and stroke and all-cause mortality than obesity (Yang et al., 2016). In a large study of Koreans, the prevalence of CVD and stroke was different between metabolically healthy and unhealthy obese subjects (Byun et al., 2016). Our results which show that obesity measurements are only fair predictors of HTN and DM lend credence to the premise that not all overweight/obese individuals are unhealthy.

The WC threshold for metabolic syndrome has been set at 31.5 in. (80 cm) for Asian women (International Diabetes Foundation, 2006; Park et al., 2009; Aekplakorn et al., 2006; Ho et al., 2003; Lin et al., 2002; Cai et al., 2013; Pua and Ong, 2005). Carba et al. (2013) suggested that the optimal WC cut-off for HTN and DM was 29.9 in. in non-overweight Filipino women and 32.6 in. in overweight women but did not present false positive rates. Our results found higher WC values in predicting HTN and DM compared to these other studies. Similarly, our conclusions regarding thresholds for WHtR differed from other studies (Ho et al., 2003; Park et al., 2009; Aekplakorn et al., 2006; Lin et al., 2002; Cai et al., 2013; Pua and Ong, 2005) of Asian female because of high false positive rates. However, as described above for BMI, lowered thresholds would be useful for screening for HTN and DM.

Our results are not surprising because Asian-specific obesity thresholds may not apply to Filipino-Americans. The intention of this paper was not to persuade the clinical readership to change anthropometric thresholds for Filipino women, rather to raise the question on whether the proposed Asian-specific cut-off points should be uniformly applied across all Asian subgroups, which are heterogeneous. Filipinos are from a mixed genetic background (Banda et al., 2015) and have a unique history with substantial Western influence. Moreover, the effect of residing in American including length of residency has an effect due to acculturation (Serafica et al., 2013; Delaveri et al., 2013). In this regard, although overweight, FAW may be healthier than their counterparts in the Philippines because they have better exercise, overall nutrition and medical care (Delaveri et al., 2013).

4.1. Limitations

The use of a cross-sectional design wherein body measurements in conjunction with HTN and DM were measured at one point in time is a limitation of this study. Since our study included those on medication the relationship of BMI, WC and WHtR at the time of diagnosis is not known. Secondly, it is possible that participant age (40–65 years), the fact that most were born in the Philippines, length of residency in USA, and genetic diversity may have influenced our outcomes and thus the generalizability of our results are not known. Another factor affecting generalizability is that our convenience sample of women volunteered for this study and had high rates of overweight/obesity. Results may differ for second-third etc. generations of Filipino-American women. Longitudinal studies of the link between anthropometric measurements and HTN and DM are needed to determine ethnic-specific effects of obesity in the development of CVD.

5. Conclusions

The three obesity measurements had similar but modest ability to predict HTN and DM in our cohort of FAW. Our results support the premise that Asian BMI and WC thresholds should be used for HTN and DM screening in Filipino-American women to reduce false negatives but whether these women, especially at older ages, should be encouraged to reach these lower thresholds needs further investigation.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflicts of interests

None.

Transparency document

The Transparency document associated to this article can be found, in the online version.

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References

Aekplakorn, W., Kosulwat, V., Suriyawongpaisal, P., 2006. Obesity indices and cardiovascular risk factors in Thai adults. Int. J. Obes. 30, 1782–1790.

American Diabetes Association, 2015. Classification and diagnosis of diabetes. Diabetes Care Retrieved from: http://care.diabetesjournals.org/content/38/Supplement_1/S8.full. Accessed October 4.

Ancheta, I.B., Battie, C., Tuason, T., Ancheta, C.V., 2012. A comparison of metabolic syndrome (MetS) risk factors in Filipino women and Filipino American women: a pilot study. Ethn. Dis. 22 (4), 404–409.

Ancheta, I.B., Battie, C.A., Tuason, M.T., Borja-Hart, N., Ancheta, C.V., 2014. The prevalence of cardiovascular risk factors and diabetes increases with a body mass index of > or $=23$ kg/m^2 in Filipino American women. Ethn. Dis. 24 (1), 48–54.

Araneta, M.R., Barrett-Connor, E., 2005. Ethnic differences in visceral adipose tissue and type 2 diabetes: Filipino, African-American, and white women. Obes. Res. 13 (8), 1458–1465.

Araneta, M.R., Kanaya, A.M., Hsu, W.C., et al., 2015. Optimum BMI cut points to screen Asian Americans for type 2 diabetes. Diabetes Care 38 (5):814–820. http://dx.doi.org/10.2337/dc14-2071.

Ashwell, M., Cole, T.J., Dixon, A.K., 1996. Ratio of waist circumference to height is strong predictor of intra-abdominal fat. BMJ 313, 559–560.

Banda, Y., Kvale, M.N., Hoffmann, T.J., et al., 2015. Characterizing race/ethnicity and genetic ancestry for 100,000 subjects in the genetic epidemiology research on adult health and aging (GERA) cohort. Genetics 200 (4), 1285–1295.

Byun, A.R., Kwon, S., Lee, S.W., Shim, K.W., Lee, H.S., 2016 Jun. Metabolic health is more closely associated with prevalence of cardiovascular diseases or stroke than obesity: a cross-sectional study in Korean populations. Medicine (Baltimore) 95 (24), e3902. http://dx.doi.org/10.1097/MD.0000000000003902.

Cai, L., Liu, A., Zhang, Y., Wang, P., 2013. Waist-to-height ratio and cardiovascular risk factors among Chinese adults in Beijing. PLoS One 8 (7), e69298.

Carba, D.B., Bas, I.N., Gultiano, S.A., Lee, N.R., Adair, L.S., 2013. Waist circumference and the risk of hypertension and prediabetes among Filipino women. Eur. J. Nutr. 52 (2): 825–832. http://dx.doi.org/10.1007/s00394-012-0390-9.

Chiu, M., Austin, P.C., Manuel, D.G., Shah, B.R., Tu, J.V., 2011. Deriving ethnic-specific BMI cutoff points for assessing diabetes risk. Diabetes Care 34 (8), 1741–1748.

Decoda Study Group, Nyamdorj, R., Qiao, Q., et al., 2008. Ferreira SR. BMI compared with central obesity indicators in relation to diabetes and hypertension in Asians. Obesity (Silver Spring) 16 (7), 1622–1635.

Delaveri, M., Sønderlund, A.L., Swinburn, B., Mellor, D., Renzaho, A., 2013. Acculturation and obesity among migrant populations in high income countries—a systematic review. BMC Public Health 13, 458.

Ho, S.Y., Lam, T.H., Janus, E.D., 2003. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. Ann. Epidemiol. 13, 683–691.

Holland, A.T., Wong, E.C., Lauderdale, D.S., Palaniappan, L.P., 2011. Spectrum of cardiovascular diseases in Asian-American racial/ethnic subgroups. Ann. Epidemiol. 21 (8), 608–614.

Hsu, W.C., Araneta, M.R., Kanaya, A.M., Chiang, J.L., Fujimoto, W., 2015. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. Diabetes Care 38 (1), 150–158.

Huang, Z.J., Zheng, C., 2015. Type 2 diabetes among 6 Asian ethnic groups in California: the nexus of ethnicity, gender, and generational status. J. Health Care Poor Underserved 26 (2 Suppl):16–35. http://dx.doi.org/10.1353/hpu.2015.0061.

International Diabetes Foundation, 2006. The IDF Consensus Worldwide Definition of the Metabolic Syndrome (www.idf.org/webdata/docs/IDF_Meta_def_final.pdf. Accessed January 4, 2015).

JAMA, 2001. Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). 285, pp. 2486–2497.

Jayawardana, R., Ranasinghe, P., Sheriff, M.H., Matthews, D.R., Katulanda, P., 2013. Waist to height ratio: a better anthropometric marker of diabetes and cardio-metabolic risks in south Asian adults. Diabetes Res. Clin. Pract. 99 (3):292–299. http://dx.doi.org/10.1016/j.diabres.2012.12.013. OLD 21.

Jih, J., Mukherjea, A., Vittinghoff, E., et al., 2014. Using appropriate body mass index cut points for overweight and obesity among Asian Americans. Prev. Med. 65:1–6. http://dx.doi.org/10.1016/j.ypmed.2014.04.010.

Karter, A.J., Schillinger, D., Adams, A.S., et al., 2013. Elevated rates of diabetes in Pacific islanders and Asian subgroups: the diabetes study of northern California (DISTANCE). Diabetes Care 36 (3), 574–579.

Kodama, S., Horikawa, C., Fujihara, K., et al., 2012. Comparisons of the strength of associations with future type 2 diabetes risk among anthropometric obesity indicators, including waist-to-height ratio: a meta-analysis. Am. J. Epidemiol. 176 (11), 959–969.

Lin, W.Y., Lee, L.T., Chen, C.Y., et al., 2002. Optimal cut-off values for obesity: using simple anthropometric indices to predict cardiovascular risk factors in Taiwan. Int. J. Obes. Relat. Metab. Disord. 26, 1232–1238.

Ma, Y., Hébert, J.R., Manson, J.E., et al., 2012. Determinants of racial/ethnic disparities in incidence of diabetes in postmenopausal women in the U.S.: the Women's Health Initiative 1993–2009. Diabetes Care 35 (11), 2226–2234.

Maskarinec, G., Erber, E., Grandinetti, A., et al., 2009. Diabetes incidence based on linkages with health plans: the multiethnic cohort. Diabetes 58 (8), 1732–1738.

Nguyen, T.H., Nguyen, T.N., Fischer, T., Ha, W., Tran, T.V., 2015. Type 2 diabetes among Asian Americans: prevalence and prevention. World J. Diabetes 6 (4):543–547. http://dx.doi.org/10.4239/wjd.v6.i4.543.

Palaniappan, L.P., Wong, E.C., Shin, J.J., Fortmann, S.P., Lauderdale, D.S., 2011. Asian Americans have greater prevalence of metabolic syndrome despite lower body mass index. Int. J. Obes. 35 (3), 393–400.

Park, S.H., Choi, S.J., Lee, K.S., Park, H.Y., 2009. Waist circumference and waist-to-height ratio as predictors of cardiovascular disease risk in Korean adults. Circ. J. 73, 1643–1650.

Park, Y., Wang, S., Kitahara, C.M., et al., 2014. Body mass index and risk of death in Asian Americans. Am. J. Public Health 104 (3), 520–525.

Pischon, T., Boeing, H., Hoffmann, K., et al., 2008. General and abdominal adiposity and risk of death in Europe. N. Engl. J. Med. 359, 2105–2120.

Pua, Y.H., Ong, P.H., 2005. Anthropometric indices as screening tools for cardiovascular risk factors in Singaporean women. Asia Pac. J. Clin. Nutr. 14, 74–79.

Serafica, R.C., Lane, S.H., Ceria-Ulep, C.D., 2013. Dietary acculturation and predictors of anthrometric indicators among Filipino Americans. SAGE Open. 3 (3), 1–15.

Shih, M., et al., 2014. Stemming the tide: rising diabetes prevalence and ethnic subgroup variation among Asians in Los Angeles County. Prev. Med. 63, 90–95.

Tuan, N., Adair, L.S., He, K., Popkin, B.M., 2008. Optimal cutoff values for overweight: using body mass index to predict incidence of hypertension in 18- to 65-year-old Chinese. J. Nutr. 138, 1377–1382.

Ursua, R., Aguilar, D., Wyatt, L., et al., 2014. Awareness, treatment and control of hypertension among Filipino immigrants. J. Gen. Intern. Med. 29 (3):455–462. http://dx.doi.org/10.1007/s11606-013-2629-4.

Wander, P.L., Boyko, E.J., Leonetti, D.L., McNeely, M.J., Kahn, S.E., Fujimoto, W.Y., 2013. Change in visceral adiposity independently predicts a greater risk of developing type 2 diabetes over 10 years in Japanese Americans. Diabetes Care 36 (2), 289–293.

Wang, E.J., Wong, E.C., Dixit, A.A., Fortmann, S.P., Linde, R.B., Palaniappan, L.P., 2011. Type 2 diabetes: identifying high risk Asian American subgroups in a clinical population. Diabetes Res. Clin. Pract. 93 (2), 248–254.

Willett, W.C., Dietz, W.H., Colditz, G.A., 1999. Guidelines for healthy weight. N. Engl. J. Med. 341 (6), 427–434.

Wulan, S.N., Westerterp, K.R., Plasqui, G., 2010. Ethnic differences in body composition and the associated metabolic profile: a comparative study between Asians and Caucasians. Maturitas 65 (4):315–319. http://dx.doi.org/10.1016/j.maturitas.2009.12.012.

Yang, H.K., Han, K., Kwon, H.S., et al., 2016 Jul 22. Obesity, metabolic health, and mortality in adults: a nationwide population-based study in Korea. Sci Rep. 6:30329. http://dx.doi.org/10.1038/srep30329.

Zhao, B., Jose, P.O., Pu, J., et al., 2015. Racial/ethnic differences in hypertension prevalence, treatment, and control for outpatients in northern California 2010–2012. Am. J. Hypertens. 28 (5), 631–639.