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Gender Differences in Obesity Indices in a 10-Year Risk for Cardiovascular Disease

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Authors' contributions

This work was carried out in collaboration between all authors. Authors TY, CAS and LMY designed the study. Authors YCC and CHL performed the statistical analysis. Authors TY, LMY, CHL and CC wrote the protocol and manuscript preparation. Authors LMY and CCC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Objective: To explore the relationship between gender-specific of obesity indices and the 10-year risk for cardiovascular disease (CVD) among elderly population in southern Taiwan.
Methods: Data were collected from Pingtung County in southern Taiwan through a health screening program, carried out from March 2007 to May 2008.The following obesity indices were included: (1) body mass index (BMI); (2) waist circumference (WC); (3) waist-to-hip ratio (WHR); (4) waist-height ratio (WHtR). The present study used the risk assessment tool of the Framingham

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Heart Study and adopted ≦10% as low risk, 11~20% as moderate risk, and >20% as high risk for CVD. Multiple logistic regression was used to predict the risk indices of obesity causing 10-year risk for CVD.

Results: A total of 831 participants were recruited in the screen program. The prevalence of the obesity indices was as follow: BMI 21.3%; WC 14.6%; WHR 47.1%; and WHtR 65.2%. A total of 118participants were found to have 10-year CVD risk groupings>20%, a prevalence rate of 14.2%. The 10-year risk for CVD is higher in men; subjects≧65 years old in both genders have a higher prevalence of moderate and high risk for CVD. After using multiple logistic regression, the results showed that men who are abnormal in WHR, WHtR, have higher moderate and high 10-year risk for CVD; In this study, men didn't find this risk in BMI and WC. Women on all four obesity indices are not the predictive factors of 10-year risk for CVD.

Conclusion: The predictive factors of 10-year risk for CVD were found in WHR and WHtR of men.

Keywords: Obesity indices; cardiovascular disease; waist-to-hip ratio; waist-height ratio.

1. INTRODUCTION

According to the updated statistics, cardiovascular disease is the leading cause of death both in United States (source: American Heart Association, 2013) and worldwide (data of the World Health Organization, 2013). Importantly, efforts to improve lifestyles, control lifestyle-related major cardiovascular risk factors, will certainly contribute to cardiovascular disease prevention [1]. However, economic development and changes in diet and lifestyle have caused an increase in overweight (body mass index, BMI≧25–29.9kg/m^2) and obese (BMI≧30 kg/m^2) populations. According to statistics from the International Association for the Study of Obesity (IASO), 1 billion overweight adults and 475 million obesity people exist worldwide.

Research in the United States has shown prevalence rates of 72.3% and 64.1% for obesity in men and women, respectively [2]; the prevalence rates for overweight and obesity in the Mediterranean are 43.9% and 18.6%, respectively [3]; in Spain, the prevalence rates for overweight and obesity are 44.6% and 17.3%, respectively [4]; the prevalence rates for overweight and obesity in the Malay Peninsula and eastern Malaysia are 33.6% and 19.5%, respectively, among which the prevalence rate for obesity in women is 22.5%, whereas it is only 14.1% in men [5]. The prevalence rates for obesity in Taiwan are the highest in Asia; according to data from the Nutrition and Health Survey in Taiwan (NAHSIT) from 1993–1996 and 2005–2008, the obesity rate for adult women rose from 31.7% to 36.9%, and that for men increased from 33.4% to 50.8% [6].

Research has indicated that as the BMI increases, obesity causes gradual increases in illness rates, most notably in chronic diseases such as cardiovascular disease (CVD), hyperglycemia, hyperlipidemia, and stroke [7,8]. A comparison of multiple-disease prevalence rates has shown that in men, 23% are of normal weight, 27% are overweight, 33% are in Class 1 obesity, 38% are in Class 2 obesity, and 44% are in Class 3 obesity; in women, 28% are of normal weight, 34% are overweight, 41% are in Class 1 obesity, 45% are in Class 2 obesity, and 51% are in Class 3 obesity [9]. Obesity continues to be a risk factor for CVD, and the chance of being diagnosed with atherosclerosis is considerably higher than for the standard population. Excessive fat accompanied with hyperglycemia and hyperlipidemia increases the dangers of developing CVD [10]. Therefore, obesity prevention has become a crucial topic in global health and medical care. In February 2014, Taiwan established the Taiwan Obesity Health Education Prevention Association to provide citizens with information on a healthy diet and weight loss. The obesity index in Taiwan currently uses BMI, waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR). BMI is the most common typical obesity index, whereas WC, WHR, and WHtR are central obesity indices [11-15]. Research has shown that various types of obesity are related to different diseases [16,17]. Few studies have employed all 4 of these obesity indices to observe disparities between sexes regarding the 10-year risk for CVD. This study investigates the relationship between obesity indices and the 10-year risk for CVD to determine indices with significant correlations, and to provide a reference for health organizations and the public, with hopes of reducing health threats caused by obesity.

2. METHODS

2.1 Study Design

The study design was cross-sectional, and the research protocol was approved by the Institutional Review Board of Meiho University. Written informed consent was obtained from all participants in the health-screening program. Participants were residents of Pingtung County in southern Taiwan, and were over 40years of age. Data were collected through a health-screening program, conducted from March 2007 to May 2008. In total, 859 adults participated in the survey; however, 28 people were excluded because of missing information on the evaluation items for the 10-year risk of CVD. The actual number of valid samples in the study was 831 adults.

2.2 Data Collection

A self-administered questionnaire was used to collect information on the sociodemographic characteristics of the study participants and their lifestyle behaviors. Physical examinations were conducted in the health center of a local teaching hospital. In addition, each participant's blood pressure was recorded, as were anthropometric measurements including height, weight, and WC. Height was measured using a stadiometer to the nearest 0.1 cm, without shoes. Weight was measured using a beam balance scale to the nearest 0.1 kg, in light clothing and without shoes; WC was measured to the nearest 0.5 cm above the iliac crests and below the lowest rib margin at minimal respiration in a standing position. BMI was calculated as the weight (kg) divided by height squared (m^2). In the current study, well-trained nurses measured the SBP and DBP two times in the right arm of seated participants according to a standardized protocol. A third blood pressure measurement was made if the first two blood pressure readings differed by more than 10 mm Hg. The average of the two closest readings was calculated to determine the reported blood pressure for each participant. The biochemical blood examination included total cholesterol, triglycerides, fasting plasma glucose (FPG), and HDL-C. Fasting venous blood samples were collected from each participant for a series of biochemistry analyses; the sample was venous blood drawn after 8 h of fasting, which was delivered to the laboratory, stored in the refrigerator, and analyzed within a week.

Definition of obesity indices:

(1). obesity: BMI≧27.0kg/m^2.
(2). abnormal WC: man:≧90cm, woman:≧80cm.
(3). abnormal WHR: man≧0.9, woman≧0.85.
(4). abnormal WHtR:≧0.5 [18,19].

2.3 Statistical Analysis

Risk assessment for determining the 10-year risk for developing CVD was performed using Framingham risk scoring. The risk factors included in the Framingham calculation were sex, age, total cholesterol, HDL-C, smoking habits, systolic blood pressure, and medication taken to treat high blood pressure [9]. Our study adopted ≧10% as low risk, 11~20%as moderate risk, and >20% as high risk for CVD. Associations between sociodemographic characteristics, lifestyle behaviors, obesity indices and their predicted 10-year risk for developing CVD were evaluated by$\chi 2$ tests and by odds ratios (ORs) and their 95% confidence intervals (CIs) derived from logistic regression analyses. All statistical tests were two sided, and values of P <0.05 were considered statistically significant. The statistical analyses were performed with Statistical Package for the Social Sciences v.17.0 (SPSS Chicago, IL).

3. RESULTS

Of the 831 research participants, 341 were men, and 490 were women; the mean±standard deviation age was 65.39±10.93 years. The prevalence of smoking, alcohol consumption, and regular exercise was approximately 13%. The prevalence of CVD risk factors was as follows: low HDL-C, 39.1%; hypertension, 67.7%; hyperglycemia, 23.5%; and triglyceridemia, 27.1%. The prevalence of obesity-related indices was as follows: BMI, 21.3%; WC, 14.6%; WHR, 47.1%; and WHtR, 65.2%. We found 118 participants to have 10-year CVD risk groupings> 20%, a prevalence rate of 14.2% (Table 1).

Table 2 shows that men have a higher 10-year risk of CVD; significantly more men were at moderate risk (11%–20%) and high risk (>20%) than were women: 47.2% versus 11.4% and 31.7% versus 2.0%, respectively. These numbers were statistically different (P <.001). More men and women over the age of 65 years had a moderate and high 10-year risk for CVD. However, no difference existed between men

and women regarding lifestyle habits (smoking, drinking, chewing betel nut, and regular exercise) and a 10-year risk for CVD. Obesity indices revealed significant differences between men and women with abnormal WHR and WHtR scores and a 10-year risk for CVD, which were evident in moderate to high risks. For women, WC was also a risk factor influencing the 10-year risk for CVD.

We employed multiple logistic regression to assess the association between obesity indices and a 10-year risk for CVD (Table 3). Adjustments were made for age. The results revealed that, among the moderate- and high-risk groups, both WHR and WHtR were strongly associated with a predicted 10-year risk for CVD. The adjusted odds ratios for moderate- and high-risk groups were as follows: WHR (OR = 2.51, 95% CI = 1.01–6.23) and (OR = 4.32, 95% CI = 1.54–12.07); and WHtR (OR = 2.75, 95% CI = 1.14–6.62) and (OR = 5.96, 95% CI = 2.07–17.34), respectively.

In women, the obesity indicator variables did not show significant associations with a 10-year risk for CVD.

4. DISCUSSION

Hypertension is an important worldwide public health challenge because of its high frequency and concomitant risks of cardiovascular and kidney disease [20]. In addition, along with its comorbidities, hypertension-related conditions have accounted for almost one third of the total causes of death in Taiwan in recent years [21]. A prior study reported that hypertension was the hard core of metabolic syndrome (MetS) associated with a significantly elevated risk of ischemic and hemorrhagic strokes [22].

However, MetS is characterized by a clustering of cardiovascular risk factors, including abdominal obesity, high blood pressure, atherogenic dyslipidemia, and increased glucose concentration [23]. Progression of the metabolic syndrome begins with obesity and/or insulin resistance. In the early stages, the metabolic risk factors are often only marginally increased, but through a period of time, particularly when obesity increases and other exacerbating factors become involved, the risk factors increase considerably. If weight can be reduced to desirable levels and if regular exercise can be sustained, then all risk factors of the syndrome will be improved, and progression to more advanced stages will be slowed [24].

Table 1. The demographic characteristics and risk factors of cardiovascular disease among study participants

Variable	Number	Percentage
Gender		
Man	341	41.0
Woman	490	59.0
Age		
<65	347	41.8
≧65	484	58.2
Smoking		
No[a]	725	87.2
Yes	106	12.8
Alcohol consumption		
No[b]	720	86.6
Yes	111	13.4
Regular exercise		
No	205	24.7
Yes[c]	626	75.3
HDL-C (mg/dL)		
Normal	506	60.9
Low high-density lipoprotein cholesterol	325	39.1
Blood pressure (mmHg)		
Normal	268	32.3
Hypertension	563	67.7
Fasting plasma glucose (mg/dL)		
Normal	636	76.5
Hyperglycemia	195	23.5
Triglycerides (mg/dL)		
Normal	606	72.9
Triglyceridemia	225	27.1
BMI (kg/m^2)		
Normal	654	78.7
Abnormal[d]	177	21.3
Waist circumference(cm)		
Normal	710	85.4
Abnormal[e]	121	14.6
Waist-to- hip ratio		
Normal	433	52.9
Abnormal[f]	386	47.1
Waist-to-height ratio		
Normal	289	34.8
Abnormal[g]	542	65.2
10-year risk for CVD		
≦10%	496	59.7
11-20%	217	26.1
>20%	118	14.2

[a]Never smoke, and ex-smoked but quit, [b]Never drink, and ex-drank but quit, [c]≥ three times/ week, 30 minutes/ time, [d]≧27 kg/m2, [e]Man: ≧90 cm; woman: ≧80 cm, [f]Man: ≧0.9; Woman: ≧0.85, g≧0.5

Table 2. Gender differences in the association between demographic characteristics, obesity indices and the 10-year risk for cardio vascular disease (n=831)

Variable	Men(n=341)				Women(n=490)			
	10-year risk for CVD				10-year risk for CVD			
	≦10%	11-20%	>20%	*P* value*	≦10%	11-20%	>20%	*P* value*
Gender	72(21.1)	161(47.2)	108(31.7)		424(86.5)	56(11.4)	10(2.0)	＜0.001
Age				＜0.001				＜0.001
<65	60(51.7)	44(37.9)	12(10.3)		225(97.4)	5(2.2)	1(0.4)	
≧65	12(5.3)	117(52.0)	96(42.7)		199(76.8)	51(19.7)	9(3.5)	
Smoking				0.267				0.384
No[a]	57(23.1)	111(44.9)	79(32.0)		412(86.2)	56(11.7)	10(2.1)	
Yes	15(16.0)	50(53.2)	29(30.9)		12(100.0)	0(0.0)	0(0.0)	
Alcohol Consumption				0.313				0.381
No[b]	53(20.9)	115(45.3)	86(33.9)		401(86.1)	55(11.8)	10(2.1)	
Yes	19(21.8)	46(52.9)	22(25.3)		23(95.8)	1(4.2)	0(0.0)	
Regular exercise				0.361				0.818
No	19(22.1)	45(52.3)	22(25.6)		105(88.2)	12(10.1)	2(1.7)	
Yes[c]	53(20.8)	116(45.5)	86(33.7)		319(86.0)	44(11.9)	8(2.2)	
BMI(kg/㎡)				0.156				0.526
Normal	63(22.9)	130(47.3)	82(29.8)		331(87.3)	40(10.6)	8(2.1)	
Abnormal[d]	9(13.6)	31(47.0)	26(39.4)		93(83.8)	16(14.4)	2(1.8)	
Waist circumference(cm)				0.875				＜0.001
Normal	69(21.2)	154(47.4)	102(31.4)		345(89.6)	33(8.6)	7(1.8)	
Abnormal[e]	3(18.8)	7(43.8)	6(37.5)		79(75.2)	23(21.9)	3(2.9)	
Waist-to-hip ratio				＜0.001				0.001
Normal	54(33.5)	77(47.8)	30(18.6)		249(91.5)	20(7.4)	3(1.1)	
Abnormal[f]	17(9.6)	83(46.6)	78(43.8)		167(80.3)	34(16.3)	7(3.4)	
Waist-to-height ratio				＜0.001				0.003
Normal	45(38.8)	55(47.4)	16(13.8)		162(93.6)	9(5.2)	2(1.2)	
Abnormal[g]	27(12.0)	106(47.1)	92(40.9)		262(82.6)	47(14.8)	8(2.5)	

[a]Never smoke, and ex-smoked but quit, [b]Never drink, and ex-drank but quit, [c]≥ three times/ week, 30 minutes/ time, [d]≧27㎏/㎡, [e]Man: ≧90 cm; woman: ≧80 cm, [f]Man: ≧0.9; woman: ≧0.85, [g]≧0.5,

**Chi-square test was used to compare the variables and adopted two-tailed test, the significant level α=0.05*

Table 3. Stratified by gender using the multiple logistic regression analysis of the association between obesity indices and predicted 10-year risk for CVD (n=831)

Obesity indices	10-year risk for CVD*	
	Moderate riskOR# (95% CI)	High riskOR (95% CI)
Men		
BMI	1.14(0.37-3.59)	1.25 (0.36-4.28)
WC	0.86(0.15-4.82)	1.13 (0.17-7.49)
WHR	2.51(1.01-6.23)	4.32 (1.54-12.07)
WHtR	2.75(1.14-6.62)	5.96 (2.07-17.34)
Women		
BMI	0.68 (0.31-1.51)	0.61 (0.10-3.82)
WC	1.98 (0.88-4.46)	1.09 (0.20-6.12)
WHR	1.03 (0.50-2.11)	2.12 (0.44-10.13)
WHtR	1.75 (0.71-4.30)	1.21 (0.20-7.15)

** Using the low risk≦10 % group as the reference group. # ORs were adjusted for age*

Health threats caused by being overweight and obesity are becoming increasingly severe in numerous countries, and are closely related to CVD risk factors. According to the Taiwan Ministry of Health and Welfare, CVD has been the second highest cause of death for the past 6 years, and is a serious threat to the lives of Taiwanese citizens, second only to malignant tumors. Research has shown a significant relationship among being overweight, obesity, and heart disease. Data from a previous cohort study showed that increases in adult weight to a BMI of 2 kg/m^2 correlates to a 1.39-fold increase in CVD risk [25].

Another study that surveyed 7191 people found a positive correlation between BMI, WC, WHR, coronary artery disease (CAD), and CVD [26]. A correlation between abnormal WHtR and CVD was also found, indicating that it could be a positive predictor for CVD [27]. A correlation exists between those with a larger WC and a protruding lower abdomen and CAD [28], and it has a clear relationship with the CVD mortality rate; the relative risks are 3.38 and 5.31, respectively [29,30]. The results from this study showed that BMI failed to reach a significant difference, and WC, WHR, and WHtR reached statistical differences with a 10-year risk for CVD. These results are similar to those obtained by Bener et al. in that the sensitivity and specificity of BMI are lower than for other obesity indices [31]. A possible reason may be the higher patient age group as the body height decreases with a reduction in spine length, and as subcutaneous fat in the limbs decreases, making it difficult to find appropriate cut points for obesity.

Other research has shown positive correlations between increases in adult body weight and obesity indices and metabolic risk factors [32], which increase the risk for CVD and metabolic syndrome [33]. This is consistent with the correlation between the obesity index and the 10-year risk for CVD found in this study. Hong et al. [32] showed that, for every 1 kg increase in body weight, the risk of metabolic syndrome increased by 15%. Other researchers have also indicated that, for each 1 kg/m^2 increase in BMI, the risk of metabolic syndrome increased 26% [32,34], and for each 1 cm increase in WC, men experienced a 6% increase in risk for diabetes, and women experienced a 4% increase [35]. Fu et al. found that, compared with those with a normal body weight ($18.5 \leq BMI < 24$), those who were overweight ($24 \leq BMI < 27$), slightly obese ($27 \leq BMI < 30$), and moderately obese ($BMI \geq 30$) were 1.64, 1.97, and 2.31 times more at risk for CVD, respectively, and 1.49, 1.87, and 2.35 times more at risk for diabetes, respectively [36]. Comparing sexes, related studies have indicated that more men have metabolic syndrome than do women [37-39]. Because metabolic syndrome is closely related to CVD, research has also shown that metabolic-syndrome-related indicators were positively associated with a 10-year risk for CVD [40]; therefore, obesity indices cause an increase in metabolic-syndrome component risk, and have a large effect on CVD occurrence. Previous research has indicated that the estimated 10-year risk for coronary heart disease is considerably higher for men than for women [41], which is similar to our study findings. Wang et al. examined 10 096 patients from mainland China, and the results indicated partial correlation coefficients of obesity indices with metabolic risk factors and the sum of risk. For both men and women, all 4 measures of obesity were strongly associated with the 4 metabolic risk factors and the sum of risk after adjusting for age. In men,

the correlation coefficients between the 4 indices and the sum of risk ranged from 0.355 to 0.397, whereas in women, a slightly lower but significant correlation was detected, with the coefficients ranging from 0.315 to 0.343. WC versus other indices had slightly higher correlation coefficients [42]. Cordero et al. analyzed information from 19 041 patients in Spain, and found that men have a higher prevalence rate for all CVD risk factors compared with women [4]. Obesity poses a serious risk to people's health and lives. Zheng et al. investigated 7 Asian countries, and found that the mortality risk for the obese is 1.5 times higher than for those of normal weight [7]. Song et al. conducted a prospective cohort study on 46 651 European patients, and found a correlation between the CVD mortality rate and obesity indices; the risk values for BMI, WC, WHR, and WHtR were 1.19, 1.29, 1.28, and 1.34 for men, respectively, and 1.37, 1.49, 1.45, and 1.45 for women, respectively [43]. Another study found that 15.4% of those who were overweight or obese accompanied by hypertension and high cholesterol will have an extremely high risk of CVD within 10 years [44].

Hypertension, hyperglycemia, and hyperlipidemia caused by obesity increase the risk for CVD and metabolic syndrome. Our findings revealed that obesity indices influenced CVD more for men than for women, particularly in WHR and WHtR. Although this is inconsistent with certain study results, this may be one limitation of this study. The participants of this study were Taiwanese adults over the age of 40 years from southern Taiwan. Their representativeness and ethnic differences may be limited. This study was designed as a cross-sectional study; thus, only the "snapshot" of association between obesity indices and 10-year risk for CVD could be evaluated. Data took the form of prevalence rates only. The analysis was purely correlational, and, therefore, this study limited our ability to make inferences about causal relationships. As well as, our study did not collect sufficient information on medical history and dietary habits from the participants. It is possible that residual confounding by these factors may also affect the obesity indices-CVD link. In the future, longitudinal studies assessing the prospective risk of cardiovascular disease and related mortality according to each anthropometric index are needed to fully clarify the resulted relationships. However, the increased CVD risk and obesity indices are consistent with the results from other studies. CVD risk is caused by hypertension, hyperglycemia, and hyperlipidemia, resulting from the swelling of adipose cells and the accumulation of visceral fat, which may result in CVD [45,46]. Therefore, preventing an increase in body weight may help reduce the mortality risk of CVD [47]. Thus, obesity is a topic that warrants immediate and continued attention.

5. CONCLUSION

This study showed that men with an abnormal WHR and WHtR are strongly correlated with a 10-year risk for developing CVD. Therefore, medical personnel must screen middle-aged and elderly populations with obesity indices for WHR and WHtR. An appropriate management of these problems can reduce the risk of CVD.

ETHICAL APPROVAL

All authors hereby declare that the study protocol has been examined and approved by the appropriate ethics committee and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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