ORIGINAL ARTICLE

Relationship of Waist Circumference, Waist-Hip Ratio and Body Mass Index as Predictors of Obesity Among Elderly Population of Sunsari and Morang Districts of Nepal

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ABSTRACT

Background: Body mass index (BMI) has gained international acceptance as a standard for recognition and classification of overweight and obesity. Waist-hip ratio (WHR) is a method for assessing abdominal fat. Waist circumference (WC) alone is a simpler way of assessing for abdominal fat and has been shown be superior to WHR in determining health risks. The aim of this study was to find out the anthropometric parameter that is associated more significantly with BMI in non-obese and obese subjects.

Materials and Methods: Data were collected from the population of 600. Each gender consisted of 150 Mongoloid and Tharu males and 150 Mongoloid and Tharu females. WC ≥102.0 cm and ≥88.0 cm; WHR ≥1.00 and ≥0.85 were classified as obese for male and female, respectively. BMI ≥26 Kg/m^2 was considered obese. Sensitivity, specificity, positive (PPV), and negative predictive values (NPV) and their 95% confidence intervals were calculated to evaluate predictive capacity.

Result: WC has a strong predictive capacity compared to WHR for obesity in both sex as WC more precisely rules out those individuals who do not have obesity (specificity 100%; 93% and NPV 82%, 94%). WHR exhibited a poor predictive ability for obesity in both sexes. In males, sensitivity and PPV both are low (36.5%; 48.9%), and in females through the sensitivity is fairly high (92.18%) the PPV is low (29.20%) as well as the specificity is low (39.40%).

Conclusion: The study provides strong evidence that WC is preferable over WHR in studies dealing with BMI.

Key words: Body mass index, obesity, waist circumference, waist-hip ratio

INTRODUCTION

Anthropometric characteristics of individuals and population are simple and strong predictors of future illness, functional impairment, and mortality; in turn they may be modified by number of factors involved such as age-related biological changes, illness, secular changes, childhood diseases, lifelong practices (sports, diet, and substance abuse), and socioeconomic factors.

The senior citizens act 2063, Nepal defines the senior citizens as "people who are 60 years and above." The retirement age for the military in Nepal is 45–48 years for lower class and for general government service 58 years; therefore, 50 years and beyond has been considered as elderly in this study.

The population of Nepal is approximately 30 million having 125 ethnic groups.[1] Political scientists Joshi and Rose broadly classify the Nepalese population into three major ethnic groups in terms of their origin: Indo-Nepalese, Tibeto-Nepalese (Mongoloid), and Indigenous Nepalese that comprised a number of tribal communities, such as the Tharus and others.

Senior citizens comprise 7.9% of the total global population. Every month 8,000,000 individuals reach 60 years of age in the world, and some 360 million people have already reached this age. By the year 2020, more than 1000 million will be over 60 years of age out of which more than two-thirds will be living in the developing countries, and that includes Nepal too.[2]

According to the population census of Nepal, June 22, 2011, senior citizen population has almost doubled from 4.6%, 2001 to 9.1%, 2011. If such growth trend continues, the Government of Nepal has to make many changes in areas of health, finance, employment, education, social relations, physical, environmental, legal, and sociological conditions because an aged nation touches on all aspects of society.

Anthropometric indicators are used to evaluate the prognosis of chronic and acute diseases, and to guide

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medical, surgical and dental intervention in the elderly.[3,4] Both underweight and obesity conditions are important risk factors for several diseases and disability in the elderly.

Increase in the elderly population of will put more pressure on the already constrained health-care resources of developing countries as aging is associated with high prevalence of chronic and debilitating diseases.

A clear understanding of trends in the nutritional status of the elderly would help to develop community-based preventive programs in public health. At present, there has been lack of available information in the related field thus causing difficulty to assist health policy makers toward evidence-based health, nutrition, and sociodemographic support guidelines. The developed countries have formulated efficient health-care system to meet the special needs of the elderly; however, such programs are presently lacking in Nepal and many developing countries.

Body mass index (BMI) has gained international acceptance as a standard for recognition and classification of overweight and obesity. Waist-hip ratio (WHR) is a method for assessing abdominal fat. This is important because increased total abdominal fat places individuals at higher risk for chronic illness regardless of their weight or BMI. Waist circumference (WC) alone is a simpler way of assessing for abdominal fat and has been shown by more recent research to be superior to WHR in determining health risks.[5]

BMI - mortality relation seems to be less pronounced in elderly than in younger populations. Explanations for this is the different association between BMI and body fatness in older compared to younger populations, as the fat-free mass declines and the body height diminishes with aging.[6] Studies have reported that WC is a better indicator of cardiovascular disease risk than BMI and WHR, in ethnically different groups.[7] The aim of this study was to find out the anthropometric parameter that is associated more significantly with BMI in non-obese and obese subjects.

MATERIALS AND METHODS

In association with the Department of Community Medicine and School of Public Health, this cross-sectional study was conducted at different places of Sunsari and Morang Districts. Data were collected from the population of Tharu and Mongoloid races belonging to both genders at the age of 50 years and above. 300 males and 300 females were included in the study. Each gender consisted of 150 Mongoloid and Tharu males and 150 Mongoloid and Tharu females. Informed consent was taken from the individual participants before collecting the data using snowball sampling technique.

Only the subjects of pure ethnic races of were included in the study whereas subjects with chronic/systemic diseases, any physical deformity or injury, and those who had a history of hospital admission in the past 2 months were excluded.

WC was measured by asking the subjects to stand comfortably with an arm hanging by side and head in Frankfurt plane. The pants and underclothing of the participant were lowered slightly for the examiner to palpate directly on the hip area for the iliac crest. The examiner stood behind the participant and palpated the hip area for the right iliac crest. The examiner marked a horizontal line at the high point of the iliac crest and then crossed the line to indicate the midaxillary line of the body. The examiner then stood on the participant's right side and placed the measuring tape around the trunk in a horizontal plane at this level marked on the right side of the trunk. The tape was parallel to the floor and was snug, but does not compressed the skin. The measurement was made at minimal respiration to the nearest 0.1 cm. WC is used to identify individuals with possible health risks based on threshold values of ≥88 cm for women and ≥102 cm for men. Men with a WC ≥102.0 cm and women with a WC ≥88.0 cm were classified as obese.[8]

Hip circumference was measured by asking the participant to stand erect with feet together and weight evenly distributed on both feet. The examiner squated on the right side of the participant and placed the measuring tape around the buttocks. The tape was placed at the maximum extension of the buttocks. The tape was checked in the front and sides so that the plane of the tape was horizontal. The zero end of the tape was held under the measurement value. The tape was held snug but not tight. The examiner took the measurement from the right side and was recorded.

The WHR was calculated by dividing the values of the WCs by hip circumference. Threshold value of WHR is taken as ≥0.85 for women and ≥1.00 for men, above which superior distribution of adipose tissue will be considered. Men with a WHR ≥1.00 and women with a WHR ≥0.85 were classified as obese.[8]

Plastic tape used in this study was manufactured by the Perfect Measuring Tape Company, 1116 Summit Street, Toledo, Ohio 43604, USA.

Standing height was measured by asking the participant to stand erect on the floorboard with his or her back to the vertical backboard of the stadiometer, as much as possible. The participant's head was maintained in the Frankfurt

Horizontal Plane position while the examiner lowered the horizontal bar snugly to the crown of the head. The measurement was read and recorded to the nearest 0.1 cm.

The participant was asked to stand on the center of the weight scale platform, and weight was recorded in kilograms.

BMI = kg/m^2 was calculated as weight (kg) divided by height in meters square (m^2). According to the World Health Organization (WHO) guidelines, BMI under 18.5 kg/m^2 is considered underweight; BMI between 18.5 and 25 kg/m^2 as normal weight; BMI between 25 and 30 kg/m^2 as preobese; and BMI more than 30 kg/m^2 as obese.[9] Earlier study has shown that the diagnosis of obesity (using reference of BMI of 30 kg/m^2) need to be lowered to 27 kg/m^2 for Malaysia and Chinese and 26 kg/ m^2 for Asian Indians (WHO, 1998).[10] Using this reference, individuals with BMI more than or equal to 26 kg/m^2 were considered obese and those with BMI <26 kg/m^2 as non-obese.

Stadiometer used in this study which is manufactured by Syber Hegne and Company AG, technical products division, Wiesenstrasses 8, CH-8008 Zurich, Switzerland. Weighing scale was manufactured by Momert Company Hungary.

Data were stored in the computer and analyzed using version 11.5 of the Statistical Package for the Social Sciences. Sensitivity, specificity, positive (PPV), and negative predictive values (NPV) and their 95% confidence intervals were calculated to evaluate whether WC and WHR appropriately identified individuals with obesity (BMI ≥26). Pearson correlation coefficient was used to test the possible correlation between the screening tools (BMI, WC, and WHR). Statistical significance was accepted at $P < 0.05$.

RESULTS

The comparison of BMI and WC among male subjects in Table 1 showed significant association of WC with BMI among male subjects ($P < 0.001$). The specificity was excellent (100%) and NPV was high (82.57%), whereas, the sensitivity was very low (20.62%), but the PPV was excellent (100%).

Table 2 also shows a significant association between WC and BMI in females ($P < 0.001$). The specificity (93.22%) and NPV (94.42%) were fairly high whereas the sensitivity and PPV were high (79.68% and 76.11%, respectively).

The comparison of BMI and WHR among male subjects in Table 3 showed a significant association ($P < 0.001$). The sensitivity was low and specificity was fairly high (36.5% and 89.87%, respectively). Similarly, the PPV was low (48%) while the NPV was fairly high (84.18%).

Table 4 also shows a significant association between WHR and BMI in female subjects ($P < 0.001$). The sensitivity was fairly high (92.18%), and the PPV was low (29.20%). The specificity was low (39.40%), and the NPV (89.7%) was fairly high.

Tables 5 and 6 depict a positive correlation between the screening parameters in male and female - BMI versus WC ($P < 0.001$) and BMI versus WHR ($P < 0.001$).

Table 1: Predictive ability of WC compared with BMI in male subjects

	BMI		Total
	Obese	**Non-obese**	
WC			
Obese	13	0	13
Non-obese	50	237	287
Total	63	237	300

WC: Waist circumference, BMI: Body mass index, χ^2: 51.12, P<0.001. Sensitivity=20.62%, specificity=100%, predictive value of positive test=100%, Predictive value of negative test=82.57%

Table 2: Predictive ability of WC compared with BMI in female subjects

	BMI		Total
	Obese	**Non-obese**	
WC			
Obese	51	16	67
Non-obese	13	220	233
Total	64	236	300

WC: Waist circumference, BMI: Body mass index, χ^2: 154.28, P<0.001. Sensitivity=79.68%, specificity=93.22%, predictive value of positive test=76.11%, predictive value of negative test=94.42%

Table 3: Predictive ability of WHR compared with BMI in male subjects

	BMI		Total
	Obese	**Non-obese**	
WHR			
Obese	23	24	47
Non-obese	40	213	253
Total	63	237	300

WHR: Waist-hip ratio, BMI: Body mass index, χ^2: 26.21, P<0.001. Sensitivity=36.50%, specificity=89.87%, predictive value of positive test=48.93%, predictive value of negative test=84.18%

Table 4: Predictive ability of WHR compared with BMI in female subjects

	BMI		Total
	Obese	**Non-obese**	
WHR			
Obese	59	143	202
Non-obese	5	93	98
Total	64	236	300

WHR: Waist-hip ratio, BMI: Body mass index, χ^2: 22.84, P<0.001. Sensitivity=92.18%, specificity=39.40%, predictive value of positive test=29.20%, predictive value of negative test=94.89%

Table 5: Correlation between the diagnostic parameters in males

Diagnostic parameters	Correlation coefficient (r)	*P* value
BMI versus WC	0.86	*P*<0.001
BMI versus WHR	0.57	*P*<0.001

BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio

Table 6: Correlation between the diagnostic parameters in females

Diagnostic parameters	Correlation coefficient (r)	*P* value
BMI versus WC	0.88	*P*<0.001
BMI versus WHR	0.58	*P*<0.001

BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio

DISCUSSION

BMI is one of the most commonly used methods of estimating body fat percentage. Application of BMI has gained increased popularity and has been directly linked to health risks and death rates in many populations, irrespective of age, sex, and ethnicity. In the late 1980s and early 1990s, the questions were raised concerning the reliability of BMI as a predictor of obesity. Findings from cross-sectional and prospective epidemiological survey have provided robust evidence that the cutoffs of BMI provided by the WHO, do not adequately reflect the overweight or obesity status of all populations.[9]

Several studies have shown that Asians have higher amounts of body fat, especially abdominal or truncal subcutaneous fat at low levels of BMI and WC than Caucasians. Thus, due to variations in body proportions, BMI may not correspond to the same body fat in different populations.[11]

WHR was previously acknowledged as the clinically accepted method of identifying patients with excess abdominal fat accumulation. However, more recently, WC alone has been suggested as being a more practical measure of intra-abdominal fat mass and total body fat. WC has been found in some studies to be more closely correlated with the level of abdominal visceral adipose tissue than is WHR.[8]

In this study, we compared WC and WHR with gold standard BMI for obesity. The specificity and NPV of WC in male and female were 100%; 93% and 82% and 94%, respectively, whereas specificity and NPV of WHR in male and female were 89%; 39% and 84%; 94%, respectively.

The study showed that WC has a strong predictive capacity compared to WHR for obesity in both sexes as WC more precisely rules out those individuals who do not have obesity (specificity 100%; 93%, NPV 82%, 94%). High NPV demonstrates that the non-obese females were correctly identified by WC.

WHR exhibited a poor predictive ability for obesity in both sexes. In males, sensitivity and PPV both are low (36.5% and 48.9%), and in females, through the sensitivity is fairly high (92.18%) the PPV is low (29.20%) as well as the specificity is low (39.40%). Thus, our results confirm the importance of the WC as a surrogate marker of obesity.

A study among older Bengali Hindus of Kolkata, India, confirmed the preference of WC over WHR as predictive index for obesity. In their study, three Indices - WC, WHR, and conicity index were undertaken to determine which measure of abdominal adiposity best relates with BMI. It was shown that in both sexes WC had the strongest correlations with BMI.[5]

In a study “Predictors of Metabolic Syndrome in the Elderly: A Review” The anthropometric indicators that showed a better performance in identifying metabolic syndrome were WC, waist height ratio (WHtR), and neck circumference. Other papers which evaluated anthropometric indicators highlight WC and WHtR as the best predictors of metabolic syndrome in the elderly, when compared to BMI and WHR.[12]

In the study conducted by Jaroszynski *et al.*, the study provides evidence that abdominal obesity is an important predictor of chronic kidney disease (CKD). As the authors found that, WhtR ≥0.6 is particularly associated with CKD in elderly females followed by WC, BMI, and WHR.[13]

In another research paper by Shahraki *et al.*, the research suggested that in clinical practice, WC can be used as a better predictor of creatinine clearance than WHR and BMI in both normal and obese, healthy women.[14]

WC can be used as an excellent screening tool compared to WHR in medical practice as it is an easy, convenient and single measurement, unlike WHR which requires two measurements waist-hip circumference that may contribute to summative measurement error.

CONCLUSION

The study provides strong evidence that WC is preferable over WHR in studies dealing with BMI.

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