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Predictive Association Of Body Composition Metrics With Obesity Related Morbid Conditions

Jagminder Kaur Bajaj[1]*, Satinderjit Singh Bajaj[2], and Surabhi Sharma[3].

[1]Professor and Head, Dept. of Pharmacology, PIMS, Jalandhar, Punjab, India.
[2]Senior Medical Officer, surgical specialist, SBLS Civil Hospital, Jalandhar, Punjab, India.
[3]DNB surgery resident 3rd year, SBLS, Civil Hospital, Jalandhar, Punjab, India.

ABSTRACT

Obesity is a public health challenge, worldwide, with many co-morbid conditions associated with it. BMI is the most frequently used standard metrics for measuring grades of severity of obesity and its association with co-morbidities. However, the visceral fat is implicated in increased risk of metabolic syndrome, diabetes, cardiovascular and many other obesity related diseases. BMI does not reflect distribution of body fat and ratio of non-fat to fat contents. Therefore, other indices of total body fat distribution measuring central adipocity as absolute & relative waist size as measured by WC & WHR respectively may be better predictors of risk of diseases than BMI. The association between such diseases & body fat metrics, are not well studied, except BMI. Therefore, present study was conducted to analyze association of raised BMI, WC & WHR with obesity related morbidities in North Indian subjects & any gender-based differences in such associations. The cross -sectional observational study was conducted on 556 adult North Indian subjects. Patients' demographic information, current illness for which patient sought medical help and presence of any obesity related illness were recorded. Patients height, weight was recorded using validated equipment and BMI calculated. WC, HC were measured using procedures given by 1988 anthropometric standardisation reference in lab investigations manual. Patients were divided into 2 groups. Group I having any of the obesity related co-morbid condition & Group II free of such diseases. BMI, WC, WHR of the two groups were compared. Out of total 556 participants, 301 (54.14%) reported obesity related comorbidities. Hypertension being the commonest followed by diabetes, arthritis, liver and thyroid dysfunction in that order. The mean age of patients with obesity related conditions was significantly more than those free of such diseases. However the difference among two genders were not statistically significant. Mean BMI of two groups was not significantly different. However, differences in mean WC and WHR were significant. The odds of developing obesity related morbid conditions increased with increase in all three metrics (BMI, WC, WHR) at a fixed age. But predictive association was significant only for WHR. All the three metrics have significant predictive association with obesity related morbidity in both genders. But association for WHR is stronger than that for WC and BMI. At constant metrics, odds of developing obesity related morbidity increased significantly by 3-3.5%, with each year increase in age and risk of obesity related morbidity is 9.3-10.9% more in females than males.

Keywords: Body metrics, body-mass index (BMI), Waist circumference (WC), Waist- hip ratio (WHR), Obesity related morbid conditions.

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Corresponding author

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INTRODUCTION

Obesity is among leading public health challenges worldwide [1]. It is associated with several comorbidities such as chronic kidney disease, nephrolithiasis, renal cancers [2-4]. Cardiovascular diseases like myocardial infarction [5], dyslipidemias [6], Type 2 diabetes mellitus, hypertension, non alcoholic fatty liver as (NAFLD), steatohepatitis (NASH), malignancies [7], joint problems and mental health problems like depression, body dissatisfaction [8,9]. Such diseases have a negative impact on 'quality of life' QOL & increase mortality.

Approximately 44 % of the global adult population has been reported to be overweight or obese & 70 % of them are from low- or middle-income countries [10]. Incidence of obesity is reported to increase even after 60 years of age [11].

WHO defines obesity as abnormal fat accumulation. It is further classified into different grades on the basis of Body Mass Index (BMI. For calculating BMI, body weight in kilograms is divided by square height in meters. However, the body fat distribution and non-fat to fat contents ratio is not correctly reflected by BMI.[12]. Therefore, many other indices of total body fat distribution like waist circumference (WC), hip circumference (HC), waist hip ratio (WHR), waist height ratio and imaging tools etc. are also used to detect visceral obesity [13]. Moreover, change in body size and composition, muscle loss with ageing, further limits the usefulness of BMI as a measure of obesity in elderly individuals [14] . In comparison to total body fat, the central or visceral fat is blamed for increasing the risk of metabolic syndrome, diabetes mellitus, cardio vascular disease [15-17]. Thus, indices measuring central adipocity as absolute & relative waist size as measured by WC & WHR respectively may be better predictors of risk of diseases than BMI , which measures generalized obesity.

Although many diseases have been linked with obesity, but the association between such diseases & various body fat measurement metrics, with exception of BMI, are not well studied [18,19] . Therefore the present study aims to analyse commonly used body composition metrics viz BMI, WC & WHR for association with obesity related morbidity in North Indian population.

Objectives: Primary objective of study was to analyse predictive association of raised BMI, WC & WHR with obesity related morbidities in North Indian subjects & any age or gender based differences in such associations.

METHODOLOGY

After approval of the institutional ethics committee, this cross -sectional observational study was conducted on 556 adult North Indian subjects visiting institutional outpatient departments for any reason. After informed consent a self structured, pre-validated case report form was filled. Patients' demographic information, current illness for which patient sought medical help and presence of any obesity related illness/es were recorded. The weight and height of patients were recorded using validated equipment. WC, HC were measured using procedures given by 1988 anthropometric standardisation reference in lab investigations manual [20].

To calculate BMI weight in kilograms was divided by square of height in meters. To calculate WHR, the WC was divided with HC, after measuring both in the same units (cm). Any results of investigations indicating presence of obesity related morbidity were also recorded and data were tabulated.

For BMI the cut off value was taken as 25. Patients with BMI >25 kg/m^2 were labelled as high BMI & those with <25 kg/m^2 were labelled as normal BMI.

For waist circumference, cut off values were different in both genders. WC of 80 cm in females and 85 cm in males was labelled as normal & above these as high WC. All study subjects were labelled as having normal or high WC.

Similarly cut off values for WHR were also different in males & females. A value upto 0.81 in females & 0.88 in males was labelled as normal and above that as high WHR

Statistics

Mean BMI, WC, WHR of patients reporting any of the 'obesity related morbid condition/s' (ORMC) and those free of it were compared using independent sample t test to see any relationship of these body fat distribution metrics with presence of co-morbidities.

Binomial logistic regression test was used to check predictive association of body metrics (BMI,WC and WHR) with presence of obesity related comorbidities, adjusted for age and gender.. Jamovi app (2.3.28) was used for statistical analysis.

RESULTS

A total of 556 patients were included in the study. Out of which 64.6% were females and rest males. Age of study group ranged from 10-89 years, with a mean age of 40.1±14.9 years.

The obesity related morbid conditions were observed in 301 (54.14%) study subjects and remaining 255 were free of such comorbidities. The diseases observed in these 301 subjects are tabulated in table 1. The most common morbid condition observed in the study population was hypertension, followed by diabetes mellitus, arthritis, liver dysfunction, thyroid disorders, renal dysfunction, menstrual irregularities, gall stones, dyslipidemia, sleep apnoea,PCOD and CAD in that order. 19 (3.4%) subjects had two comorbid conditions (diabetes with hypertension being the commonest comorbidities in 8), whereas 4 subjects had three coexistent morbid conditions.

The mean age of subjects with ORMCs was 43.5 years. It was significantly more ($p<0.001$) than that of subjects free of such conditions (36.1 years).

Genderwise distribution of subjects showed that obesity related morbidities were more frequently encountered in females (55.2%) than males (52.2%)., however these differences between two genders were not statistically significant ($p=0.516$)

Obesity is measured by certain parameters of body fat distribution like Body mass index (BMI), waist circumference (WC) and waist:hip ratio (WHR). All the three parameters viz BMI, WC & WHR showed higher values in patients having some obesity related disease than those free of such diseases. However, these differences were statistically significant for mean WC and mean WHR, and not for BMI. (Table 2).

Binomial logistic regression analysis for the three-body metrics (BMI, WC, WHR) adjusted for age is represented in Table 3. It shows that at a fixed age , a unit increase in BMI and WC is associated with increased odds of developing obesity related morbidity by 24% and 27.7% respectively. But these are not statistically significant ($p>0.005$). Fig 1. Shows Probability of comorbidity with increasing BMI at a fixed age=50 years. Conversely Fig 2 shows increasing probability with increase in age at an ideal BMI=25.

However, unit increase in WHR significantly increases odds of developing 'obesity related disease' by 57% (p 0.019). Odds of developing obesity related morbidity increase by 3-3.5% with each year increase in age ($p<001$). Fig 3. Predicted probability of obesity related morbidity with increasing waist circumference at different ages.and Fig 4. Predicted probability of obesity related morbidity at different ages with increasing waist: hip ratio (WHR).

Binomial logistic regression analysis, adjusted for gender, shows that all the three body metrics viz BMI, WC and WHR have significant predictive association with obesity related morbid conditions. (Table 4). The odds of developing obesity related diseases increase by 49.1%, 65.7% and 89% with unit increase in BMI, WC and WHR respectively. Increase in risk of obesity related morbidities is 9.3-10.9% more in females than males for constant metrics, but this difference is not significant.

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Table 1: Obesity related morbid conditions

Name of the morbid conditions	number of patients reporting the disease	% age of total study population(N=556)
Hypertension	76	13.6
Diabetes	72	12.9
Arthritis	45	8.0
Liver dysfunction	32	5.7
Thyroid dysfunction	30	5.3
Renal dysfunction	23	4.1
Menstrual irregularities	15	2.6
Gall stones	12	2.1
Dyslipidemia	10	1.7
Sleep apnoea	5	0.9
PCOD	2	0.3
CAD	1	0.2

Tabe 2 : Comparison of Parameters of Body fat distribution in patients with or without diseases

Subset of patients	BMI Mean±S.D.	WC Mean±S.D.	WHR Mean±S.D.
Patients with comorbidity N= 301	28.1±5.88	93.0±12.4	0.884±0.112
Patients without comorbidity N= 255	27.6±6.01	87.3±13.1	0.866±0.0831
p value **unpaired t test**	p=0.271	***p<0.001****	***p= 0.038****

Table 3: Predictive association of body metrics with obesity related morbity, adjusted for age.

Predictor	Estimate	Odd's ratio	% increase in disease with unit rise in predictor	p value
BMI	0.2145	1.239	24%	0.237
WC	0.2441	1.277	27.7%	0.236
WHR	0.4487	1.57	57%	**0.019***
Age	0.0334-0.0345	1.03-1.035	3-3.5%	**<0.001***

Binomial logistic regression analysis
Predictive accuracy of model : moderate with AUC(0.658-0.665)

Table 4: Predictive association of body metrics with obesity related morbity, adjusted for gender.

Predictor	Estimate	Odd's ratio	% increase in disease with unit rise in predictor	p value
BMI	0.3996	1.491	49.1%	**0.022***
WC	0.505	1.657	65.7%	**0.010***
WHR	0.6081	1.89	89%	**<0.001***
Gender	0.0719-0.103	0.99- 1.093	9.3-10.9 %	>0.05

Binomial logistic regression analysis
Predictive accuracy of model : low with AUC(0.555-0.557)

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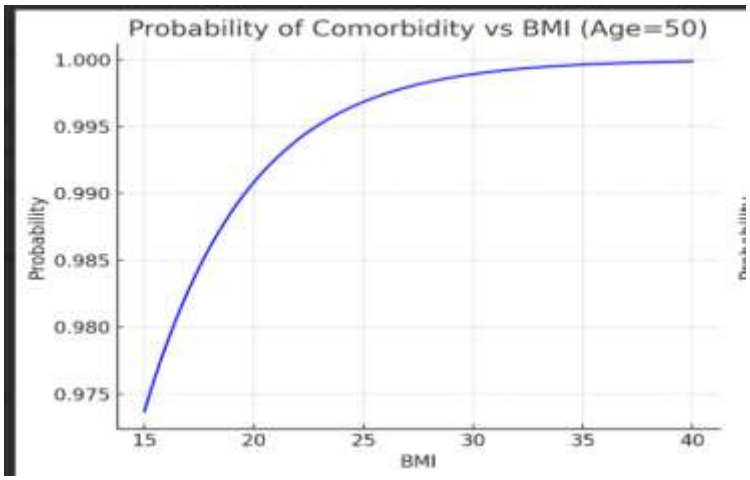

Figure 1: Probability of comorbidity with increasing BMI at a fixed age=50 years.

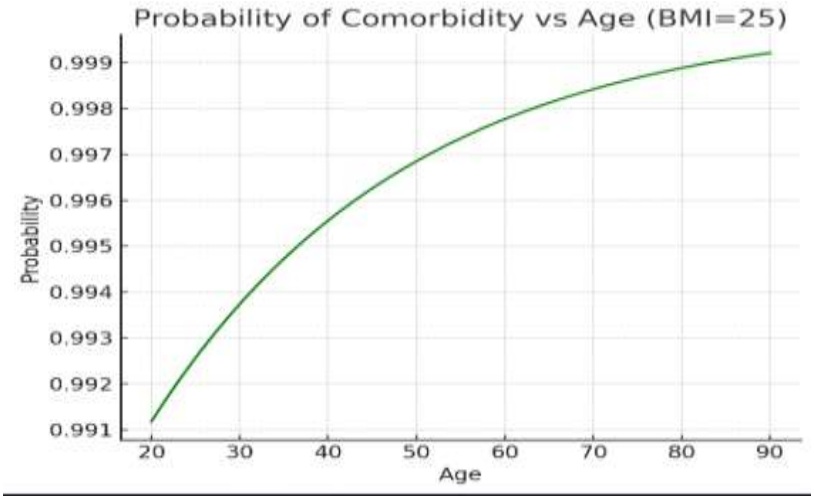

Figure 2: Increasing probability with increase in age at ideal BMI=25

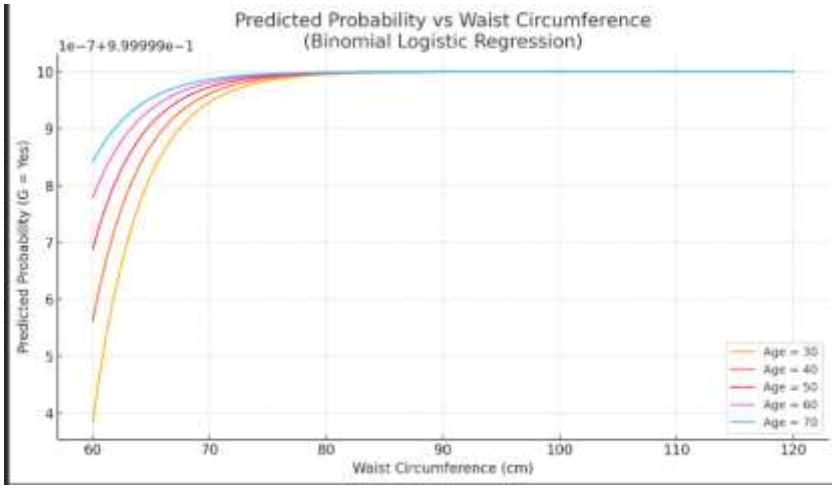

Fig 3. Predicted probability of obesity related morbidity with inceasing waist circumferance at different ages.

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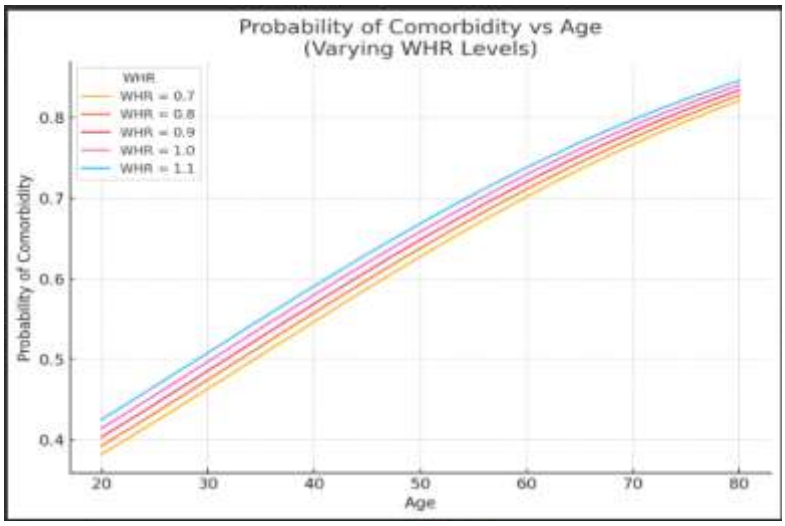

Figure 4: Predicted probability of obesity related morbidity at different ages with inceasing waist: hip ratio (WHR).

DISCUSSION

BMI has long been used as a measure of obesity and associated with increased risk of obesity related morbidity and mortality. But several researchers challenged the use of BMI for reflecting body fat distribution as well as ratio of non –fat to fat contents. Thus, several other indices such as WC, HC, WHR, WHtR were increasingly linked with obesity related diseases. The present study aimed at observing the association of three important parameters (BMI, WC and WHR) with obesity related diseases.

In our study group of 556 individuals, 54.14% had obesity related morbidities. The mean age of patients having obesity related morbidities in our study group was 43.5 years, which was significantly more than the mean age of disease free subjects. Odds of developing obesity related morbidity were found to increase by 3-3.5% with each year increase in age (p<. 001). Prevalence of multiple comorbidities has been reported to vary from 33-44% in obese men and 41-51% in obese women, with increasing grades of obesity from grade 1 to grade 3[21].

Moreover, such morbidities were more prevalent among females than males, although differences were not significant. Increase in risk of obesity related morbidities is 9.3-10.9% more in females than males for constant metrics. Choudhary M et al had reported abdominal obesity and related comorbidities in as many as 50-60% women in age 30-49 years. [22] A higher prevalence of metabolic syndrome (32.1%) in females than in males (24.7%) is reported by Nouri keshtkar [23] and also by other researchers [24,25].

Similarly, many researchers have reported higher prevalence of various other diseases in elderly, obese individuals. Such as Anand A etal reported higher risk of bone diseases in obese females >45 years of age [26]. Kohrt WM etal reported development of insulin resistance and TYPE 2 DM in obese older adults. [27] Steven J reported hypertension and dyslipidemias in elderly patients who had a higher BMI[6]. Dey DK reported CAD risk to be higher in obese patients >70 years of age [28].

Mean BMI of patients with or without obesity –related diseases were not significantly different, whereas mean WC and mean WHR of those suffering from such diseases were significantly more than those of disease-free subjects. Folsom AR and WOO J have also denied any significant association of BMI with all cause mortality in older adults [29,30]. However their results are different from present study for WC, as they reported WC to have no significant association with all cause mortality.

Binomial logistic regression analysis, adjusted for age, shows that a unit increase in WHR significantly increases odds of developing 'obesity related disease' by 57% (p 0.019), at a fixed age. Morbidity risk increased with BMI and WC also, but was not statistically significant. Binomial logistic

regression analysis, adjusted for gender, shows that all the three body metrics viz BMI, WC and WHR have significant predictive association with obesity related morbid conditions.

Anne D had also reported increased risk of myocardial infarction with all 3 parameters increasing BMI (especially in patients in highest quintiles > 28.2 kg/m2) , WC and WHR]. [31] But varying results have been obtained by different researchers in this context among males and females. Rexrode KM et al reported positive association of waist girth (WC) with risk of CAD. [32] Younghoon S et al reported WHR to be a better predictor for chronic kidney disease than BMI. However, risk of suffering from CKD was 1.28 times higher in patients with BMI > 27 kg/m2 than those with BMI 22.0-23.6 kg/m2. [33] Similarly Preethi S et al also reported a graded relationship between WHR and all cause mortality in females (relative hazard 1.28 per 0.1 increase in WHR) and only a threshold relationship in case of males (relative hazard 1.75 for WHR > 1.0). [34] Tice J et al reported a monotonic relationship between WHR and mortality in women [35].

Such a strong relationship observed in case of females could be because of greater fat mass increase with WHR in women than men, with increasing age. In our study the observed gender-based differences might be secondary only to female preponderance in the study group. Thus further studies should be planned to include an equal number of male and female participants.

Summary of results

- The mean age of subjects having 'obesity related morbid conditions 'was significantly more than others in the study group.
- Mean WC & WHR were significantly higher in participants having obesity related diseases than in those free of such diseases.
- The odds of developing obesity related morbid conditions increased with increase in all three metrics (BMI,WC,WHR) at a fixed age. But predictive association was significant only for WHR.
- Odds of developing obesity related morbidity increased significantly by 3-3.5%, with each year increase in age ,at constant metrics.
- All the three metrics have significant predictive association with obesity related morbididity in both genders. But association for WHR is stronger than that for WC and BMI.
- For constant metrics, the increase in risk of obesity related morbidity is 9.3-10.9% more in females than males. But the difference was not significant.

CONCLUSIONS

All the three parameters of body fat distribution studies viz BMI, WC and WHR have significant association with obesity related diseases, more so in females. The predictive associations are more pronounced for WHR followed by WC and BMI in that order.

Limitations of study

- The diseases were self-reported by patients and were not confirmed by appropriate investigations in all the patients.
- The number of female patients was much more than male patients, which might have reflected on results while analyzing both genders together.
- Further studies using equal male and female participants and confirmation of diagnosis by investigations may provide more useful information.

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