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Research Article

OBESITY STUDY AMONG PATIENTS IN EASTERN INDIA SUGGESTS WC AND WHR AS BETTER INDICATORS

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ABSTRACT

Objective: The study was conducted to investigate an independent relationship among waist circumference (WC), waist-hip ratio (WHR) and body mass index (BMI).

Method*:* A survey was carried out among 50 random patients of age group 30-65 (30 females and 20 males) from divisional railway hospital, south east central railway, Raipur, Chhattisgarh. The patients were categorized into underweight, normal-weight, overweight, and obese according to the international adult body mass index cut-offs. The survey followed an interactive sessions with these patients through questionnaire. Later, the survey data's were executed with statistical analysis (ANOVA test).

Result*:* The result extracted on the basis of alternate hypothesis, suggest that body mass index is independent of waist-hip ratio. Waist circumference also explicates the risk of obesity as it indicates the changes in intra-abdominal fat.

Conclusion*:* On the whole it can be farsighted not to draw on BMI as it summarizes body size. The alternatives WC and WHR more clearly define the health risks associated with excess body fat accumulation.

Keywords: Obesity; Waist-hip ratio; Body mass index; Waist circumference; ANOVA.

INTRODUCTION

Obesity is a chronic and stigmatizing medical condition that has become a major health problem in most industrialized countries because of its high prevalence, causal relationship with serious medical illnesses, and economic impact. Indian Asians have a high prevalence of the metabolic syndrome compared with Europeans and it seems to be highly heritable [1]. In most of the countries, about 20-30% of the adult population is amenable to metabolic syndrome. In Asian Indians while dealing with metabolic syndrome, clinicians consider obesity measures, metabolic profiles and dietary fatty acids simultaneously [2]. The term obesity, describe body weight which is much greater than what is normal or healthy. An obese person is one, having the body fat greater than normal. Unhealthy weight gain occurs when energy intake from food is greater than energy expended through physical activity. Environmental, cultural, genetic and lifestyle factors all contribute to overweight and obesity [3]. Physical inactivity and overeating are the major contributors to the problem of obesity [4, 5].

Obesity is a natural consequence of over nutrition and sedentary lifestyle. In the developing countries, with the enhancement in economic status, there is an increase in the prevalence of obesity and metabolic syndrome is observed in adults and children. The main causes are increasing urbanization, nutrition transition, and reduced physical activity [6]. Obesity is associated with many diseases that include cardiovascular diseases (CVDs), hypertension, hyperlipidemia, diabetes mellitus, colorectal cancer, breast cancer, and endometrial cancer [7]. It has been investigated that the accumulation of adipose tissue predominantly in the visceral cavity plays a major role in the development of metabolic syndrome and CVD [8]. The association of birth weight with body mass index provides an implication for the early origins of both obesity and cardiovascular disease [9]. Hypertension and obesity combine to increase the cardiac work significantly. In hypertension the increased myocardial work stems from an increased left ventricular pressure generated; whereas in obese patients the increased myocardial work is secondary to an increased stroke volume. Thus the obese hypertensive patients suffer from markedly increased stroke work because of a combination of volume and pressure overload state [10]. The increase in the prevalence of type 2 diabetes is closely linked to the augmentation in obesity. About 90% of type 2 diabetes is attributable to excess weight [11]. It has been implied that preventing weight gain can reduce the risk of many cancers. Even a weight loss of only 5 to 10 percent of total weight can provide health benefits [12]. Other diseases associated with obesity include sleep apnea, abdominal hernias, varicose veins, gout, gall bladder disease, respiratory problems including pickwickian syndrome (a breathing blockage linked with sudden death), and liver malfunction [13].

It has been reviewed that BMI is a measure of weight (for height) rather than a measure of body fat [14]. Excess fat, rather than excess weight, is linked to obesity-related ill health [15]. Also, BMI does not describe where fat is deposited, and as intra-abdominal fat is thought to be more likely to cause ill health than fat deposited in other parts of the body, hence waist circumference has been undertaken as an obvious measure in consolidating obesity. Therefore this study, explains the advantages of the WHR and waist measurement over BMI.

MATERIALS AND METHODS

Study subjects

A survey was conducted among 50 random patients from divisional railway hospital, south east central railway, Raipur, Chhattisgarh and was followed by an interactive sessions through questionnaire with patients. Using the questionnaire, information were collected on the level of health conditions, subjective experience of work load, habitual physical activity, family history and further was followed by anthropometric measurements.

Diagnostic criteria

Parameters that explains the risk of obesity on the basis of BMI and WHR: The International Classification of adult weight status was used to classify by body mass index (BMI): (1) underweight (<18.5), (2) normal weight (18.5–24.9), (3) overweight (25.0–29.9), and (4) obese (>30.0) [16, 17].

Central obesity was estimated using the hip-to-waist ratio (WHR) that refers to the comparative distribution of body fat by measuring the hip circumference at its widest part (in centimeters) and dividing that into the waist circumference (in centimeters) [18] and was categorized as low, reference, moderate and high separately for men <0.85, 0.85–<0.95, 0.95–<1 and ≥1 and women <0.7, 0.7–<0.8, 0.8–<0.85 and ≥0.85 respectively and these cutoff values were recommended by WHO [19]. High risk waist- circumference for men and women was >40 inch (>102 cm) and >35 inch (>88 cm) respectively [20].

Anthropometric measurements

During the interactive sessions, standing height in centimeters and weight in kilograms were recorded for all subjects using stadiometer and electronic weight scale and BMI was then calculated. Waist and hip girths (cm) were measured with an anthropometric tape over light clothing. Waist girth was measured at the minimum circumference between the iliac crest and the rib cage and hip girth at the maximum width over the greater trochanters and WHR was then calculated.

Statistical analysis

In statistics, the variances have been used as a measure of how far a set of numbers were dissipating from each other. Here the data were pooled together and managed on an excel spreadsheet into the following readings: Age, BMI, and WHR. For analyzing the variance between the groups, one-way classification method was followed to find out whether a difference exits among them or not. Hence in one-way classification, all the observations were classified according to one factor and were exhibited column wise. Table 1 shows, the j^{th} observation in the i^{th} sample which was denoted by $y_{ij.}$

Table 1: Distribution of samples estimating total and mean

Sample 1	Sample 2	Sample i	Sample k
y_{11}	y_{21}	y_{i1}	y_{k1}
y_{12}	y_{22}	y_{i2}	y_{k2}
.	.	.	.
.	.	.	.
.	.	.	.
y_{1j}	y_{2j}	y_{ij}	y_{kj}
.	.	.	.
.	.	.	.
.	.	.	.
y_{1n}	y_{2n}	y_{in}	y_{kn}
Total = T_1	T_2	T_i	T_K
mean = $\bar{y}_1$	$\bar{y}_2$	$\bar{y}_i$	$\bar{y}_k$

Again, Mean Error! Reference source not found. **Error! Reference source not found.**.

Then, between-samples sum of squares (or) treatment sum of squares was given as follow: SS(Tr) =**Error! Reference source not found.**, where n_i is number of elements in each column.

Total sum of squares (SST) = **Error! Reference source not found.** .

Where, C = **Error! Reference source not found.** is called the correction term.

The error sum of square SSE was obtained by SSE= SST-SS(Tr). The result obtained in was summarized by means of analysis of variance (anova) as mentioned in table 2, where, N= sum of the values of all items.

Table 2: Anova table for one-way classification

Source of varience	Degrees of freedom	Sum of squares	Mean squares	Ratio F (variance)
Treatment	k-1	SS(Tr)	MS(Tr)= $\frac{SS(Tr)}{k-1}$	
Error	k(n-1)=N-k	SSE	MSE= $\frac{SSE}{k(n-1)}$	$\frac{MS(Tr)}{MSE}$
Total	Kn-1	SST	………	

Interpretation

1. If calculated F value was less than table value of F (**Error! Reference source not found.**), then null hypothesis can be accepted and thus follows that there was no significant difference between samples.

2. If calculated F value was greater than table value of F (**Error! Reference source not found.**), then alternative hypothesis was accepted and thus follows that there was significant difference between samples.

ETHICS

All the 50 patients were informed and explained about the purpose of the survey. A written permission letter was provided by the medical officer of divisional railway hospital, south east central railway, Raipur, Chhattisgarh for the obesity survey to be carried out.

RESULTS

All the 50 samples are categorized into following study subjects as obese male and female, overweight male and female, normal male and female and underweight female on the basis of the cut-off values of BMI and WHR. In table 3, all obese female are in high health risk as their BMI and WHR is >30.0 and ≥0.85 respectively. But in comparison with obese female, overweight and normal females are also in high health risk. For overweight female, their BMI is ≥25 (25.00 - 29.99) and so can be professed as pre-obese females along with higher WHR similar to that of obese females. And again for normal females too, although they have normal BMI their WHR is similar to obese females and so it can be interpreted that all 30 females are in the higher health risk, even if they are obese, overweight or normal. In accordance with all females, table 3 also illustrates all males with normal risk factor even if they are obese, overweight or normal.

Table 3: Body mass index, waist – hip ratio and related health risk

S. No	Age	BMI	WHR	Health risk
1	54	31.2	0.85	Back joint & knee pain.
2	58	32.2	0.90	Headache, high BP, joint back & knee pain, asthma.
3	53	30.9	0.91	Severe depression, high BP, sleeps apnea, back joint & knee pain.
4	40	31.2	0.91	High BP, heart problem, joint pain, severe headache.

Table 3 (contd)

S. No	Age	BMI	WHR	Health risk
5	36	34.5	0.91	Joint pain.
6	44	38.6	0.91	Diabetes, joint &knee pain, & swelling of foot.
7	55	31.3	0.96	High BP, knee, foot pain.
8	33	33.4	0.96	Fibro-adenosis (breast tumor) can be cured by medication.
9	45	30.3	0.99	Shortness of breath.
10	33	31.9	0.96	Normal
11	40	35.3	0.96	High BP, swelling of feet, migraine & depression.
12	34	28.7	0.91	Joint back & knee pain, asthma
13	37	28.4	0.92	Foot pain
14	55	27.5	0.93	High BP, joint back & knee pain, asthma
15	31	27.6	0.93	Joint pain
16	50	29.3	0.93	Joint pain ,severe headache
17	30	25.1	0.96	Joint back & knee pain

Table 3 (contd)

S.no	Age	BMI	WHR	Health risk
18	47	28.2	0.96	High bp, joint pain
19	46	29.5	0.96	Severe depression
20	30(pregnant)	25.3	0.98	Low BP, foot back & knee pain
21	30	25.9	0.98	High BP
22	36	26.3	0.96	Normal
23	62	27.9	0.97	Normal
24	52	28.8	0.97	Back pain
25	47	29.8	0.97	Normal
26	33	27.8	0.98	Normal
27	52	29.3	0.98	Joint & knee pain
28	70	26.6	0.99	Mild high BP, joint, knee and foot pain.
29	35	28.6	0.99	High BP
30	67	27.8	0.90	Normal
31	43	25.5	0.94	High BP
32	66	23.6	0.88	Normal

Table 3 (contd)

S.no	Age	BMI	WHR	Health risk
33	55	21	0.91	Muscle pain
34	55	20.7	0.93	Joint back & knee pain
35	68	18.8	0.95	Normal
36	58	19.2	0.96	High BP, joint pain ,sleep apnea
37	49	19.6	0.99	Normal
38	46	23	0.99	Normal
39	39	23.3	0.84	Joint pain
40	30	20.5	0.85	Normal
41	39	23.8	0.77	Low BP, foot pain, migraine, depression
42	34	24.3	0.81	Normal
43	40	19.8	0.86	Normal
44	34	25.9	0.90	Joint and back pain
45	58	23	0.91	Normal
46	39	24.9	0.91	Back and knee pain
47	54	22	0.93	High BP, diabetes , sleep apnea

Table 3 (contd)

S.no	Age	BMI	WHR	Health risk
48	41	24.6	0.93	Normal
49	65	22.9	0.97	Asthma, join pain
50	35	16.4	0.79	Normal

Serial no.1-9 and 10-11 represents obese female (high risk) and obese male (moderate risk) respectively. Serial no. 12-21, 22-29, 30-31 explain overweight female with high risk, overweight male with moderate risk and overweight male with low risk respectively. Again serial no. 32-38, 39-40 and 41 shows normal female (high risk), normal female (moderate risk), normal female (low risk) respectively. Serial no.42-49 depict normal male (low risk). Serial no.50 shows underweight female.

Thus mentioning an independent relationship between BMI and WHR thus statistically analyzed through one-way classification. For some observation as mentioned in table 4, i.e. obese female, the result with respect to BMI and WHR are mentioned below. Here BMI and WHR is represented as independent random sample (k=2) and each of size (n=9).

Table 4: Observations of obese female patient

S. no	BMI	WHR
1	31.2	0.85
2	32.2	0.90
3	30.9	0.91
4	31.2	0.91
5	34.5	0.91
6	38.6	0.91
7	31.3	0.96
8	33.4	0.96
9	30.3	0.99
TOTAL	**Error! Reference source not found.**=293.6	**Error! Reference source not found.**=8.27

Grand total T = **Error! Reference source not found.**= 301.87.

Correction term C = **Error! Reference source not found.** = **Error! Reference source not found.**=5062.52

Sum of squares (SST) =

$[(31.2)^2+……+(30.3)^2+(0.85)^2+...+(0.90)^2]-5062.52 = 4671.12$.

Treatment sum of squares SS(Tr) = **Error! Reference source not found.** – 5062.52 = 4522.95

Error sum of squares (SSE) = SST-SS(Tr) = 148.16.

Following the above calculations, anova table for obese female is represented in table 5.

Table 5: Anova table for obese female patients

Source of varience	Degrees of freedom	Sum of squares	Mean squares	Ratio F (variance)
Treatment	k-1=2-1=1	SS(Tr) = 4522.95	MS(Tr) = **Error! Reference source not found.**=4522.95	
Error	k(n-1)= 2(9-1)=16	SSE =4671.12	MSE=**Error! Reference source not found.**=9.26	**Error! Reference source not found.**= 488.43
Total	17	SST = 148.16	………	

Here $F=488.43>4.49=F_{0.05}$ for the degree of freedom (1, 16) and therefore alternative hypothesis is accepted, thus showing independent relationship between BMI and WHR at 0.05 level of significance. Similarly, the characteristic F-values (F-calculated and F-critical) of all the study subjects (male and female) are shown in table 6 thus explaining the variance for obese male and female, overweight male and female, normal male and female and hence showing BMI is independent on WHR.

Table 6: Characteristic f-values of the study subjects

Subject	F-calculated	F-critical
Obese females (high risk)	488.43	4.49
Obese male (moderate risk)	368.64	18.512
Overweight females (high risk)	2786.385	4.4138

Overweight male (moderate risk)	3868.433	4.600
Overweight male (low risk)	500.440	18.512
Normal females (high risk)	802.332	4.747
Normal female (moderate risk)	226.177	18.512
Normal male (low risk)	1087.839	4.600

Later, table 7 provide information of waist circumference of all 50 patients, which also proves that females are in high health risk even if they are obese, overweight or normal, as they show waist circumference is >88cm , compared to male who are in lower risk.

Table 7: Waist circumferences of patients

S. No.	Age	Waist measurement (cm)
1.	40	100
2.	55	103
3.	54	104
4.	44	104
5.	53	105
6.	58	106
7.	33	117
8.	36	117
9.	45	122
10.	33	108
11.	40	108
12.	37	92
13	30	95
14.	34	96.5
15.	31	100
16.	30	103
17.	50	105
18.	30	108
19.	55	110
20.	47	115
21.	46	115

Table 7 (contd)

S. No.	Age	Waist measurement (cm)
22.	67	88
23.	52	92
24.	43	96
25.	70	97
26.	62	97
27.	36	100
28.	47	101
29.	33	102
30.	35	102
31.	52	102
32.	49	88
33.	68	89
34.	55	89
35.	66	91
36.	58	93
37.	55	93
38.	46	102
39.	30	75
40	39	79
41	39	81
42	35	71

Table 7 (contd)

S. No.	Age	Waist measurement (cm)
43.	34	75
44.	40	79
45.	54	90
46.	34	92
47.	58	95
48.	41	95
49.	39	97
50.	65	98

Serial no.1-9 and 10-11 represents obese female and male respectively. Serial no. 12-21, 22-31 shows overweight female and male respectively. Again serial no. 32-38, 39-41 and 43-50 explains normal female with high risk, normal female with low risk and normal male respectively. Serial no. 42 depicts underweight female.

DISCUSSION

The health risks associated with central fat distribution are now universally recognized than that of BMI [21]. The practical measurement of the body fat distribution parameters are nearly a half-century after the central fat risks are first reported [22]. Waist-to-hip ratio is the most popular index for assessing central obesity [22]. Here the data of present study demonstrates that there is no relationship between BMI and WHR, both are independent of each other. It has been explained on the basis of two hypotheses: Null hypothesis-BMI is dependent on WHR and Alternate hypothesis-BMI is independent on WHR.

As it has been clearly observed from table 3 that women are in higher health risk with respect to WHR, even though they are obese, overweight or normal and men are in low health risk. Thus on the basis of this, one-way classification is done to determine the variance. Following the results in table 6, which explains that F-calculated > F-critical and thus interprets that BMI and WHR both undergo an independent relationship with each other.

Recently, various organizations have proposed indices of waist circumference to assess central obesity. The use of WC has gained popularity in recent years. It is increasingly being accepted as the best anthropometric indicator of abdominal adiposity and is one of the five anthropometric indices for diagnosing obesity. Furthermore, WC is a better index as compared to BMI and is used as a measure of obesity [23, 24]. BMI has traditionally been the chosen indicator for measuring body size as well as composition. It is also meant to diagnose overweight and underweight. But later, alternative measures that reflect abdominal adiposity, such as WC, WHR and WHtR (waist-height ratio) have been suggested to be superior to BMI in predicting metabolic abnormalities like CVD, diabetes, hypertension as abdominal obesity is based largely on the increased visceral adipose tissue is associated with a range of metabolic abnormalities [25]. It has been framed by the NIH guidelines that the health risk increases in a graded fashion when moving from the normal-weight through obese BMI categories, and that within each BMI category men and women with high WC values are at a greater health risk than are those with normal WC values [26]. Thus, it is assumed that BMI and WC have independent effects on obesity related co-morbidity. WC is a strong predictor of both abdominal and non-abdominal fat and it seems reasonable to suggest that, for a given WC value, higher BMI values may not indicate an increased health risk. WC is positively associated with health risk [27] and it has been clearly explained in table 7, where females are at the higher risk irrespective of obese, overweight and normal as compared to males.

The World Health Organization (WHO) describes obesity as one of the modern epidemics, which put the lives of a considerable part of human population at risk and predicts that in 21st century it is going to be reformed into a plague with raging consequences for public health and social insurance systems. Since 1948, the WHO has included obesity in its list of diseases. Although obesity represents the second most prevalent cause of death, it surely can be prevented [18, 23 and 28]. Both WHO and the World Bank have highlighted the increasing burden of economic impact of obesity in several countries [23]. Obesity is associated with the rapidly emerging adults NCDs (non-communicable diseases) where they have replaced infectious disease with obesity and it has become the leading cause of death [23, 28]. It seems that, changes in the WC reflects changes in the risk factor for cardiovascular diseases (CVD) and other forms of chronic diseases, even though risk seem to vary in different population. Therefore WHR may remain a useful research tool and the individual can also be identified as being at the increased risk of obesity related illness by using the WC alone as an initial screening tool [23]. Thus it can be surmised that BMI is a relatively weak substitute for measuring the percentage of body-fat and thereby, obesity [29].

CONCLUSION

The findings of the present study suggest that WHR, WC, BMI are independent variables in predicting the health risk. And on the whole, obesity assessed by waist-hip ratio is a better predictor than BMI for interpreting the metabolic risk. Furthermore, the study explains that the waist-to-hip (WTH) ratio is a common measure of fat distribution and their usefulness of WC and WHR for prediction of disease risk. WHR/WC can help a person to track his/her weight loss progress and also can be served as a warning of estimated health risk for troubles related to being overweight, such as heart disease, type two diabetes, arthritis, and cancers like colon, breast, esophageal, uterine, ovarian, kidney, lung and pancreatic cancer.

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