Research Article

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Journal of Food, Nutrition and Population Health

2017
Vol.1 No.3:30

Comparison of Clinical Variables with Adiposity Indices in Identifying Cardiovascular Disease Risk: A Cross-Sectional Cohort Study from South India

Mary Regi*

Mount Carmel College, Bangalore, Karnataka, India

***Corresponding author:** Regi M

mary.regi@gmail.com

Mount Carmel College Bangalore, Karnataka, India

Tel: 080 2226 1759

Citation: Regi M (2017) Comparison of Clinical Variables with Adiposity Indices in Identifying Cardiovascular Disease Risk: A Cross-Sectional Cohort Study from South India. J Food Nutr Popul Health Vol.1 No.3:30

Abstract

Introduction: Obesity is the leading risk factor for the development of cardiovascular diseases (CVD). Globally, over 1.9 billion adults are overweight and around 650 million are obese. Several studies have explored the usefulness of various anthropometric measures in evaluating the CVD risk. However, the literature evidence indicates the lack of clear consensus on the appropriate use for these anthropometric measures for evaluating the risk.

Objective: To compare the different clinical variables with the fat adiposity indices as measures of cardiovascular risk, and to verify the agreement of fat adiposity indices with ABSI.

Methodology: The cross-sectional cohort study was conducted at a diagnostic center in south India for a period of one year. Demographic details such as age, gender, educational qualification, occupation and socioeconomic status were obtained for all the participants. Measurements of height, weight, waist circumference and hip circumference were performed with SECA scale. The subjects were grouped into 4 distinct quartiles each based on BMI, BAI, ABSI and DEXA tissue fat percentage. The agreement of different fat adiposity indices with ABSI was verified by Kappa method. All statistical analysis was performed using Medcalc software.

Results: The comparison of variables like age, gender, height, weight, waist circumference, hip circumference, waist-to-hip ratio and waist-to-height ratio among the 4 quartiles of different indices showed that waist circumference significantly differed in the fourth quartile for all the anthropometric measures. The variables like weight, hip circumference and waist-to-height ratio also differed significantly among the quartiles for measures like BMI, BAI and DEXA tissue fat percentage.

Conclusion: ABSI has fair agreement with measures like BMI and DEXA tissue fat percentage.

Keywords: Cardiovascular diseases; CVD; ABSI; BMI; BAI; DEXA tissue fat percentage

Received: Novemeber 09, 2017; **Accepted:** Novemeber 28, 2017; **Published:** December 05, 2017

Introduction

Obesity is one among the major risk factors for the development of cardiovascular disease and other non-communicable diseases [1]. Excess adiposity plays a crucial role in inducing the development of cardiovascular risk factors like hypertension, dyslipidemia and diabetes mellitus [2]. As per the 2016 fact sheet published by World Health Organization, over 1.9 billion adults were overweight and more than 650 million were obese worldwide. Moreover, the fact sheet has also highlighted that the worldwide mortality rate associated with overweight and obesity is more when compared to underweight [3]. Several studies have evaluated the efficacy of various anthropometric measures in assessing the risk associated with developing cardiovascular diseases. Body mass index (BMI) and waist circumference are the extensively used anthropometric measures for assessing cardiovascular risk [4]. It has been well established that the risk of heart disease and stroke increases with the increase in body mass index. Lam et al. have compared the effectiveness of measures like BMI, body adiposity index (BAI) and waist-to-height ratio in predicting the risk factors associated with cardiovascular diseases. The study has demonstrated that BMI is a better indicator of the overall measure of body adiposity than body adiposity index [2]. Additionally, body mass index along with waist-to-height ratio has been deduced to provide significant clinical benefits in assessing patients with cardiovascular risk factors [2]. Furthermore, studies have indicated that BMI or excess total body fat have lesser influence in predicting the risk of cardiovascular diseases compared to adipose tissue distribution and body shape [5]. Maessen et al. [4] have reported that the newly devised indices like a body shape index (ABSI) have an insignificant role in determining the presence of cardiovascular diseases or its risk compared to BMI and waist circumference. However, the researchers have concluded on the capability of the measure in determining the variations in circulating levels of insulin and the lipoprotein is more accurate than BMI [6]. The literature evidence indicates that there is no clear consensus on the appropriate use for these anthropometric measures for evaluating CVD risk [7]. The present study compared the different clinical variables with the fat adiposity indices, as measures of cardiovascular risk. In addition, the study also verified the agreement of fat adiposity indices with ABSI.

Patients and Methods

The cross-sectional cohort study was conducted at a diagnostic center in southern India from 2014 to 2015. The study was approved by the institutional ethics committee and informed consent was obtained from all the participants. The study subjects were selected based on random convenience sampling method. Both male and female patients belonging to the age group of 25-45 years were included in the study. Pregnant women, lactating mothers and patients above 45 years and below 25 years were excluded. Demographic details such as age, gender, educational qualification, occupation and socioeconomic status were obtained for all the participants. Data pertaining to frequency of food intake, general health, social habits and lifestyle were collected through a questionnaire. The subjects were screened for the risk of cardiovascular disease using the Framingham risk score. Biochemical parameters like lipid profile and blood sugar levels were evaluated. Measurements of height, weight, waist circumference (WC) and hip circumference (HC) were performed with SECA scale. The height and weight of the subjects were measured using the SECA stadiometer and SECA electronic weighing scale respectively. The values were further used to calculate ABSI, BAI, BMI, waist-to-hip ratio and waist-to-height ratio for all the subjects. The tissue fat percentage of each subject was obtained from dual-energy X-ray absorptiometry (DEXA).

The following Krakauer and Krakauer formula was used for calculating ABSI [8]:

$$ABSI=WC/(BMI^{2/3} \times height^{1/2})$$

BAI was calculated using the following formula [9]:

$$BAI=(HC \text{ in cm}/(\text{height in m})^{1.5}) -18$$

BMI was calculated using the below mentioned formula [10]:

$$BMI=\text{weight in kg}/ (\text{height in m})^{2}.$$

The subjects were grouped into 4 distinct quartiles each based on BMI, BAI, ABSI and DEXA (tissue fat percentage).

Statistical Analysis

The data are presented as mean ± sd or median (range) for continuous data and as counts for categorical data. The clinical variables were compared for different fat adiposity groups by ANOVA for normal data, Kruskal-Wallis test for non-normal data and chi square test for count data. The agreement of different fat adiposity indices with ABSI was verified by Kappa method. $P<0.05$ was considered as statistically significant for all analysis. The statistical analysis was performed using Medical software.

Results

A total of 40 patients (24 men and 16 women) belonging to the age group of 25-45 years were selected for the study. The mean age (years), height (cm), weight (kg), waist circumference (cm) and hip circumference (cm) of the subjects were 35.96, 162.4, 68.46, 87.5 and 99, respectively. The waist and hip circumferences ranged from 71-129 cm and 84-124 cm respectively. The male to female ratio of the subjects was 1: 0.6. The distribution of subjects into the various quartiles for ABSI, BMI, BAI and DEXA were as follows: ABSI: group I: 10, group II: 10, group III: 10, and group IV: 10; BMI: group I: 2, group II: 15, group III, 15; and group IV: 8; BAI: group I: 0, group II: 11; group III: 13; and group IV: 16, and DEXA: group I: 10; group II:10; group III: 10; and group IV: 10. Upon comparison of variables like age, gender, height, weight, waist circumference, hip circumference, waist-to-hip ratio and waist-to-height ratio among the different ABSI quartiles, a significant difference in the waist circumference (P 0.011) and waist-to-hip ratio ($P<0.001$) was noted. The post-hoc analysis revealed that the subjects belonging to the fourth quartile (100.4 ± 15.2) had a significantly higher mean waist circumference compared to those belonging to the first quartile

(84.8 ± 8.9). The mean waist-to-hip ratio was significantly higher in the subjects of the fourth quartile (1 ± 0.07) than those belonging to the other three quartiles **(Table 1).** However, other variables like age, gender, height, weight, hip circumference and waist-to-height ratio did not differ significantly among the four ABSI quartiles. The comparison of the variables among the BMI quartiles showed that the variables like weight (<0.001), waist circumference (0.01), hip circumference (<0.001) and waist-to-height ratio (<0.001) differed significantly among the four groups. The post-hoc analysis revealed that the subjects belonging to the third (71.3 ± 6.3) and fourth (83.4 ± 10.4) groups had significantly higher mean weight compared to those belonging to the first (51.5 ± 0.1) and second (59.9 ± 8) groups. Similarly, the hip circumference of subjects belonging to the third (100) and fourth (112) groups were significantly higher than those belonging to the first (87.7) and second (96) groups. In addition, the average waist circumference and waist-to-height ratio was significantly higher in the fourth group compared to other three groups **(Table 2).** The other variables like age, gender, and height and waist-to-hip ratio did not show significant variation among the four groups. The comparison of the BAI groups for the various clinical factors showed significant variation in factors like weight (0.027), waist circumference (0.013), hip circumference (0.001) and waist-to-height ratio (0.003). None of the subjects belonged to the BAI first quartile. However, the post-hoc analysis did not reveal any significant variation for weight among the groups. The mean waist circumference of the subjects belonging to the fourth group (96.6 ± 13.8) was significantly higher than the second group (84.4 ± 7.0). The hip circumference and waist-to-height ratio of the subjects belonging to the fourth group was significantly higher compared to the subjects belonging to the second and the third groups **(Table 3).** The other variables like age, gender, and height and waist-to-hip ratio did not vary significantly among the four quartiles. The comparison of the DEXA quartiles for the various factors showed that all the variables, except age and waist-to-hip ratio, were significantly different among the four quartiles. However, the post-hoc analysis revealed no significant difference among the groups for height. The mean weight was noted to be significantly higher in the subjects belonging to the fourth quartile (76.0 ± 11.5) compared to those belonging to the first quartile (59.3 ± 8.0). The waist circumference was significantly higher in the subjects belonging to the fourth quartile (95) when

Table 1 Comparison among ABSI groups for different clinical variables.

Factors	Group I (n=10)	Group II (n=10)	Group III (n=10)	Group IV (n=10)	P value
Age (years)	32.6 (22.9-55.0)	32.45 (27.5-46.2)	36.2 (25.5-42.4)	42.45 (28.0-55.9)	0.189
Gender M/F	5/5	6/4	6/4	7/3	0.842
Height (cm)	161.45 ± 12.0	161.25 ± 7.9	162.4 ± 7.3	164.5 ± 10.2	0.866
Weight (kg)	76 ± 9	67.6 ± 7.9	62.5 ± 9.4	67.67 ± 17.5	0.088
Waist circumference (cm)	84.8 ± 8.9	87.3 ± 6.4	88.2 ± 10.2	100.4 ± 15.2	0.011
Hip circumference (cm)	99.8 ± 13.7	98.7 ± 6.6	98.4 ± 9.4	100.7 ± 10.3	0.955
Waist-to-hip ratio	0.85 ± 0.09	0.9 ± 0.04	0.9 ± 0.05	1 ± 0.07	<0.001
Waist-to-height ratio	0.52 ± 0.07	0.54 ± 0.04	0.54 ± 0.08	0.61 ± 0.1	0.085

M: Male, F: Female.

Table 2 Comparison among BMI groups for different clinical variables.

Factors	Group I (n=2)	Group 2 (n=15)	Group 3 (n=15)	Group 4 (n=8)	P value
Age (years)	34.5 (33-36)	32 (22.9-48.9)	35.4 (27.5-55.9)	35.5 (27-44)	0.488
Gender (M/F)	2/0	10/5	9/6	3/5	0.348
Height (cm)	169.75 ± 1.8	163.76 ± 8.2	162.3 ± 8.5	158.1 ± 12.6	0.36
Weight (kg)	51.5 ± 0.1	59.9 ± 8	71.3 ± 6.3	83.4 ± 10.4	<0.001
Waist circumference (cm)	79.5 (77-82)	84 (78-99)	88 (71-103)	99 (80-129)	0.01
Hip circumference (cm)	87.7 (86.3-89)	96 (84-103)	100 (86-106)	112 (102-124)	<0.001
Waist-to-hip ratio	0.9 ± 0.05	0.9 ± 0.06	0.9 ± 0.07	0.91 ± 0.14	0.99
Waist-to-height ratio	0.47 ± 0.01	0.52 ± 0.04	0.54 ± 0.06	0.65 ± 0.1	<0.001

M: Male, F: Female.

Table 3 Comparison among BAI groups for different clinical variables.

Factors	Group 1 (n=0)	Group 2 (n=11)	Group 3 (n=13)	Group 4 (n=16)	P value
Age (years)	0	34.8 ± 8.4	37.1 ± 9.0	35.8 ± 8.2	0.798
Gender (M/F)	0	4/7	9/4	11/5	0.171
Height (cm)	0	163.8 ± 7.9	164.9 ± 9.4	159.4 ± 9.7	0.244
Weight (kg)	0	63.7 ± 9.4	64.8 ± 10.3	74.6 ± 13.2	0.027
Waist circumference (cm)	0	84.4 ± 7.0	87.1 ± 9.4	96.6 ± 13.8	0.013
Hip circumference (cm)	0	93.3 ± 7.6	96.7 ± 6.2	105.8 ± 10.3	0.001
Waist-to-hip ratio	0	0.9 ± 0.07	0.9 ± 0.06	0.91 ± 0.10	0.942
Waist-t-height ratio	0	163.8 ± 7.9	164.9 ± 9.4	159.4 ± 9.7	0.003

M: Male, F: Female.

Table 4 Comparison among DEXA groups for different clinical variables.

Factors	Group I (n=10)	Group II (n=10)	Group III (n=10)	Group IV (N=10)	P value
Age (years)	34.5 ± 8.8	39.5 ± 10.2	32.4 ± 4.1	37.3 ± 8.5	0.246
Gender (M/F)	10/0	9/1	4/6	1/9	<0.001
Height (cm)	166.6 ± 6.7	165.4 ± 9.3	161.4 ± 9.3	156.2 ± 9.0	0.046
Weight (kg)	59.3 ± 8.0	69.9 ± 10.1	68.5 ± 13.6	76.0 ± 11.5	0.015
Waist circumference (cm)	83 (77-99)	91.5 (83-101)	84 (78-100)	95 (71-129)	0.041
Hip circumference (cm)	90.7 ± 5.7	98.7 ± 5.4	99.3 ± 6.0	108.9 ± 11.7	<0.001
Waist to hip ratio	0.93 ± 0.04	0.93 ± 0.05	0.86 ± 0.05	0.89 ± 0.13	0.261
Waist to height ratio	0.5 ± 0.05	0.5 ± 0.05	0.5 ± 0.4	0.6 ± 0.1	0.003

M: Male, F: Female.

Table 5 Kappa agreement of different adiposity indices with ABSI.

Adiposity indices	Kappa value	95% confidence interval
BMI	-0.362	-0.633 to -0.0917
BAI	0.011	-0.253 to 0.274
DEXA	-0.32	-0.612 to -0.0285

compared to those in the first (83) and third (84) quartiles. Additionally, the waist circumference was significantly higher in the subjects belonging to the second quartile (91.5) compared to those in first (83) quartile. The mean hip circumference was significantly higher in the subjects belonging to the fourth quartile (108.9 ± 11.7) compared to the first (90.7 ± 5.7) and second (98.7 ± 5.4) quartiles (P<0.001). The mean waist-to-height ratio was also found to be significantly higher in the subjects belonging to the fourth quartile (0.6 ± 0.1) compared to the first (0.5 ± 0.05) and third (0.5 ± 0.4) quartiles (P 0.003) **(Table 4).** The kappa agreement of adiposity indices with ABSI showed that BMI and DEXA had fair agreement, whereas, BAI had only poor agreement **(Table 5).**

Discussion

Evaluation of the subjects using the four adiposity indices namely ABSI, BMI, BAI and DEXA tissue fat percentage has noted that the waist circumference was significantly higher in the subjects belonging to the upper quartiles. In addition, significant variations in weight, hip circumference and waist-to-height ratio were also noted for measures namely BMI, BAI and DEXA tissue fat percentage among the different quartiles. Literature review indicates contradictory findings on the use of simple anthropometric measures as predictors for CVD risk. Several studies have delineated ABSI as an inferior indicator of the CVD hazard when compared to indices like waist-to-height ratio and waist circumference. In concurrence to these findings, an earlier study by Regi and Bhargavi [11] have concluded waist-to-height ratio and waist circumference as better predictors of cardiovascular risk than ABSI, despite ABSI being directly proportional to waist circumference. However, the current study shows that ABSI could notably classify the subjects based on waist circumference. Savva et al. [12] have specified that the risk factors for cardiovascular diseases in children can be better predicted by waist circumference and waist- to-height ratio. The study by Adegbija et al. [13] conducted in aboriginal Australians, concluded that the risk of cardiovascular diseases is directly proportional to the waist circumference. Similarly, the study by Wang et al. [14] indicated that the rate of cardiovascular diseases increases proportionally with the quartiles of waist circumference. The present study has also noted WC to be significantly higher in subjects belonging to the upper quartiles of ABSI, BMI, BAI and DEXA tissue fat percentage. Literature studies have shown that clinical variables like waist circumference and waist- to-height ratio are strongly correlated with BMI [12]. The present study has also noted that the variables were significantly higher in the subjects belonging to the fourth quartile of BMI compared to the other three quartiles. Savva et al. [12] have attributed the predictive potential of waist circumference and waist -to-height ratio to their capacity in predicting the lipid and lipoprotein values. Waist circumference has been asserted as a significant predictor of the levels of total cholesterol, HDL-cholesterol and LDL-cholesterol, and waist-to-height ratio as a significant predictor of total cholesterol, LDL-cholesterol and triglycerides. On comparison of the predictive power of BMI, ABSI and waist-to-height ratio for cardiovascular disease risk in Iranian population, Haghighatdoost et al. [15] have concluded that ABSI is a week predictor for cardiovascular disease risk. In contrast, the 10-year population-based follow-up study by Bozorgmanesh et al. [16] has found ABSI as a better indicator of cardiovascular disease risk than BMI, waist circumference, waist- to-hip ratio and waist- to-height ratio. Similar findings were reported by Malara et al. [6] on evaluating the association between metabolic risk factors and anthropometric measures like BMI and ABSI in young sedentary men. The study has found that ABSI is more significantly associated with circulating total cholesterol and insulin than BMI. Additionally, the plasma levels of insulin, total cholesterol, non-HDL-cholesterol and LDL-cholesterol were found to be significantly higher in the subjects belonging to the upper ABSI quartiles compared to those in the lower ABSI quartiles. The present study has also noted a fair agreement of ABSI with BMI and DEXA tissue fat percentage. Schousboe et al. [17] have concluded DEXA-visceral adipose tissue as a good predictor of cardiovascular disease events, as the measure is significantly correlated with insulin resistance and HDL cholesterol. The study by Barreira et al. [18] noted that anthropometric measures like weight, hip circumference, waist circumference, waist-to height-

ratio, BMI and BAI are significantly correlated with fat mass and percentage of fat measured by DEXA and cardiovascular disease risk factors. Several studies have proposed BAI as an inadequate indicator of cardiovascular diseases risk [19] have suggested BMI as a better indicator of cardiometabolic risk than BAI [20]. The study by Lam et al. have discussed BAI as the least correlated measure with CVD risk factors compared to WC, BMI, waist- to-hip ratio and waist- to-height ratio [2]. In summary, the present study has shown that ABSI agrees with measures like DEXA tissue fat percentage and BMI in evaluating CVD risk. ABSI has also been found to have poor agreement with BAI for predicting the risk. The present study holds greater significance, as there is very less literature evidence from south Indian population on the association between different clinical variables and fat adiposity indices. The limitations of the study include smaller sample size, inability to generalize the results due to the selection of sample from a convenient population, and the lack of evaluation of the complete cardiovascular risk estimation parameters like cholesterol. Further studies involving larger sample size are warranted to corroborate the findings.

Conclusion

The present study shows that ABSI is a reliable measure for the evaluation of cardiovascular disease risk and its efficacy is comparable to that of DEXA tissue fat percentage and BMI.

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