

# Abdominal volume index: a predictive measure in relationship between depression/anxiety and obesity

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## Abstract

**Background:** Obesity is a risk factor for mood disorder (such as depression and anxiety). We aimed to assess application of A Body Shape Index (ABSI) and abdominal volume index (AVI), as new indices of obesity to evaluate the relationship between obesity and depression/anxiety.

**Methods:** This cross sectional study was conducted on 307 overweight and obese women (249 females, 58 males) 20-60 years in Iran in 2017-2018. The anthropometric measures including weight, waist circumference, hip circumference, body fat and derived values of body mass index, waist-hip ratio, AVI and ABSI were evaluated. HADS questionnaire for depression and anxiety completed.

**Results:** Prevalence of depression was 36.1% in women; men 24.1%; overweight 28.1%; obese 36.5 % and central obesity 33.7%. Anxiety was apparent in 27.1% of overweight 30.3 % obese and 29.6% central obesity. People with depression and anxiety had higher WC, BF and AVI. ABSI had no significant correlation with depression/anxiety. The odds of depression (1.06; 95% CI, 1.02-1.12) and anxiety (1.06; 95% CI, 1.01-1.11) were elevated with increase AVI.

**Conclusion:** Our results suggested that AVI as an indirect measure of abdominal obesity along with WC and BF could be useful in predicting the relationship between obesity and depression/anxiety.

**Keywords:** Abdominal volume index; anxiety; depression.

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## Introduction

Excessive body fat deposition which is defined as obesity has a dramatic growing trend worldwide and it could increase all-cause mortality<sup>1</sup>. Obesity is considered as a chronic and complex disease which contributes in a wide range of adverse health outcomes such as cardiovascular, visual and psychiatric disorders<sup>2-4</sup>.

Depressive disorders are the major psychiatric problem worldwide which will account 11% of total burden of disease by 2020 according to world health organization report<sup>5</sup>. The interrelationship between obesity and depression frequently has been studied in the literature although still it is not fully understood that how they are

linked? Some investigations suggest that depression is more prevalent among obese people particularly females while paradoxically there is some evidence linking obesity to lower degree of depressive symptoms and anxiety<sup>6-8</sup>. However there are several proposed mechanisms on the pathways explaining the obesity and depression association among them dysfunction in HPA axis has attracted much interest<sup>9,10</sup>. Actually it has been suggested that depression and anxiety can induce the activity of HPA axis which in turn increases adrenal cortisol secretion<sup>11</sup>. Some evidence has also supported the obesity, particularly abdominal type, to be developed following over-activation of HPA axis<sup>12</sup>.

Many studies seeking the correlation between obesity and depression/anxiety have used BMI as a predictor index of higher fat accumulation while it has been confirmed that however BMI is the best tool for body fat estimation it has some limitations in indication of how this fat mass is distributed over the body<sup>13</sup>. Some evidence account fat distribution particularly abdominal adiposity as a more predictive index for the association between obesity and diseases specially mood illnesses including depression and anxiety<sup>14</sup>. Zhao et al study suggested that abdominal obesity among overweight and obese individuals was significantly associated with increased depressive symptoms<sup>15</sup>. Lee et al reported that depressive mood is associated with visceral fat, not with subcutaneous fat, in overweight premenopausal women<sup>16</sup>. There are some indices locating fat mass including Waist-height ratio (WHtR), Waist-hip ratio (WHR) and the newer ones like a body shape index (ABSI) and abdominal volume index (AVI)<sup>17,18</sup>. In current study we hypothesized that these new indices are more useful in detecting the potential link between obesity and depression/anxiety.

## Methods

In the cross sectional study, participants selected by simple random sampling from Golestan referral and governmental Hospital of Ahvaz Jundishapur University of Medical science in Ahvaz, Iran from October 2017 to March 2018. Among eligible participants in this study, Forty-eight individuals, including Patients with psychological diseases other than depressive disorders and people consuming alcohol or psychotropic drugs were excluded from our investigation. Finally, 307 individuals (249 females and 58 males) between 18 to 60 years of age with BMI above 25 kg/m<sup>2</sup> and history of failure to lose

extra body weights, to be enrolled to this study. The study was approved by the ethical committee of AJA University of Medical Sciences. At the beginning all the entrants completed written informed consent and another demographic questionnaire. Sample size was calculated according to previous study<sup>15</sup> and using the following formula: Sample size =  $D [Z_{2(1-\alpha/2)} \times p \times (1-p)] d^2$ .

D= design effect of 2 was used to account for increased variance due to the cluster sampling technique.  $Z_{1-\alpha}$  = the z-score corresponding to the desired confidence level of the estimate. A 95% confidence level (95%CI) was chosen, corresponding to  $Z_{1-\alpha} = 1.96$ .

Body weight (to the nearest 0.1 kg) and standing height (to the nearest 0.1 cm) were measured (Inbody230, Biospace, Korea). The scale was calibrated before each measurement. BMI was calculated with using weight (kg) divided by height (m) squared. Waist circumferences (WC) and hip circumferences (HC) measurement was evaluated according to the protocol presented in another study<sup>19</sup>. The WHR was obtained by dividing WC to HC. A body shape index (ABSI) =  $WC / (BMI^{2/3} \text{ height}^{1/2})$  and abdominal volume index (AVI) =  $[2 \text{ cm (waist)}^2 + 0.7 \text{ cm (waist-hip)}^2] / 1,000$ , are new indices of body fat percentage and abdominal fat accumulation which we calculated according to previous studies<sup>20,21</sup>. Moreover tetra polar Bioelectrical Impedance Analysis (BIA) was applied to evaluate body fat and lean body mass in participants. Evaluation of depressive symptoms was done using Hospital Anxiety and Depression Scale (HADS) which helps patients to assess their symptoms of both depression and anxiety during the last week they passed by themselves. This scale is a questionnaire consists of two groups of questions, seven for each part, indicating anxiety and depression in a clinical setting. Each subscale of HADS has an overall score range 0 to 21 which the higher score indicates the higher severity of anxiety or depression as follows: 0-7 no symptoms, 8-10 mild, 11-14 moderate and 14-21 severe<sup>22</sup>. An observer was used to evaluate the equipment, methods and assessment technics used in this study.

## Statistical analyses

All the analyses were performed using IBM SPSS statistics for windows version 21.0 (IBM Corp, 2012). Kolmogorov-Smirnov test was used to examine whether the variables have normal distribution or not. For compare means over two groups, Kruskal-Wallis and One-Way ANOVA tests were used. Chi square, Wilcoxon signed-

rank and independent samples t tests were used to compare means between groups. Spearman and Pearson tests were used to assess correlation markers for anthropometric measurements.  $P < 0.05$  was considered as statistical significant in all the analyses.

## Results

This study included 249 females and 58 males aged be-

tween 18 to 60 years (mean  $39.98 \pm 11.77$ ). We didn't have missing value in our study. Means of calculated BMI and ABSI for all the participants were  $32.83 \pm 5.06$  and  $0.0100 \pm 0.002$  respectively. We showed the distribution of the values as median for WC, percentage of body fat, and AVI (cm, 38.25% and 22.05 respectively). Table 1 has summarized analysis of anthropometric measurements and adiposity indices among quartiles of ABSI.

**Table 1.** Anthropometric characteristic of participants for anxiety status according to HADS score

Variables	ABSI				
	Q1	Q2	Q3	Q3	P-V
Age, years	39.3±11.2	39.1±10.9	40.7±11.7	40.6±13.1	0.75
Weight (Kg)	107.6±15	90.4±9.3	81.4±7.2	72.5±7	<0.001
BMI (kg/m <sup>2</sup> )	39.5±3.8	33.6±1.8	30.7±1.5	27.4±1.8	<0.001
WC* (cm)	120 (111-127.75)	107 (100.5-113)	102 (98-107)	97.5 (92-103)	<0.001**
HC (cm)	119.7±11.3	111.6±8.3	108.4±6.2	103.8±5.9	<0.001
WHR	1.00 ± 0.11	0.96 ± 0.09	0.94 ± 0.07	0.94 ± 0.08	<0.001
BFP*	42.2 (38.3-44.9)	39.7 (35.1-41.7)	38.4 (35.2-39.9)	35 (31.8-36.9)	<0.001**
AVI	29 (24.6-32.6)	22.8 (20.2-25.5)	20.8 (22.8-19.2)	19 (16.9-21.2)	<0.001**

BMI; Body Mass Index, WC; Waist Circumference, HC; Hip Circumference, WHR; Waist-hip ratio, PBF; percentage body fat, ABSI; A Body Shape Index, AVI; abdominal volume index

\*These variables are expressed as median and interquartile range and others are expressed as mean ± SD.

\*\* P values were derived from Kruskal-Wallis and others from One-Way ANOVA.

Characteristics of the study population according to status of depression using HADS-depression score are shown in Table 2. The results of our study showed that 36.1% of women and 24.1% of men, 28.1% of overweight and 36.5 % of obese subjects, 33.7% of subjects with central

obesity and 38.5% of ones without central obesity had some degrees of depression based on HADS-depression score. Moreover 76.6% of people with depression had apparent symptoms of anxiety which was proved using scores resulted from HADS-anxiety questionnaire (Table 2).

**Table 2.** Qualitative characteristics of study population according to status of anxiety and depression

Variables		Anxiety			Depression		
		No (N=217)	Yes (N=90)	P- value*	No (N=203)	Yes (N=104)	P-value*
<b>Anxiety/</b>	No, n (%)	182 (89.7%)	21 (10.3%)	0.001**	182 (83.8%)	35 (16.2%)	0.001**
<b>Depression</b>	Yes, n (%)	35 (33.7%)	69 (66.3%)		21 (23.3%)	69 (76.6%)	
<b>Sex</b>	Male, n (%)	46 (79.3%)	12 (20.7%)	0.15	44 (75.9%)	14 (24.1%)	0.08
	Female, n (%)	171 (68.7%)	78 (31.3%)		159 (63.9%)	90 (36.1%)	
<b>Age groups</b>	< 40, n (%)	113 (72.0%)	44 (28.0%)	0.87	105 (66.5%)	53(33.5%)	0.27
	40-< 60, n (%)	90 (69.2%)	40 (30.8%)		88(68.2%)	41 (31.8%)	
	≥ 60, n (%)	14 (70.0%)	6 (30.0%)		10(50%)	10 (50%)	
<b>BMI</b>	Overweight, n (%)	70 (72.9%)	26 (27.1%)	0.47	69 (71.9%)	27 (28.1%)	0.15
	Obese, n (%)	147 (69.7%)	64 (30.3%)		134 (63.5%)	77 (36.5%)	
<b>WC</b>	No Central Obesity, n (%)	19 (70.4%)	8 (29.6%)	0.28	8 (61.5%)	5 (38.5%)	0.72
	Central Obesity, n (%)	198 (76.9%)	92 (23.1%)		195 (66.3%)	99 (33.7%)	

BMI; Body Mass Index, WC; Waist Circumference

\*P -values were derived from chi square test

The anthropometric measurements of samples for status of anxiety and depression according to HADS-anxiety score are presented in table 3. Application of HADS-anxiety for seeking symptoms of anxiety showed that 31.3% of women and 20.7% of men were anxious. Furthermore 27.1% of overweight and 30.3 % of obese subjects, and also 29.6 % and 23.1% of participants with or without central obesity experienced some degrees of anxiety.

The investigation of correlation between depression/anxiety HADS scores and anthropometric indices measurements indicated that people with anxiety had higher WC (107 vs. 103), percentage of body fat (39 vs. 38.05) and AVI (22.89 vs. 21.21) compare to normal group. In addition, individuals with high score of depression had higher WC (108 vs. 103) and AVI (23.32 vs. 21.21) compare to normal individuals (Table 3).

**Table 3.** Demographic and anthropometric characteristic of participants for status of anxiety and depression according to HADS anxiety score

Variables	Anxiety status			Depression status		
	Normal (n=217)	Anxious (n=90)	P-V	Normal (n=203)	Depression (n=104)	P-V
Age (years)	40.02 ± 11.76	39.89 ± 11.92	0.91	39.85±11.69	40.24±12.03	0.79
Weight (Kg)	87.33 ± 16.31	89.67 ± 16.79	0.21	87.22±16.25	89.55±16.83	0.26
BMI (kg/m <sup>2</sup> )	32.59 ± 4.97	33.41 ± 5.26	0.23	32.51±5.11	33.46±4.69	0.14
WC* (cm)	103 (97-112)	107 (99-117.75)	0.02**	103(98-112)	108(98.25-119.25)	0.02**
HC (cm)	110.27 ± 9.81	112.51 ± 10.38	0.08	110.26±10.09	112.22±9.78	0.11
WHR	0.96 ± 0.10	0.97±0.09	0.43	0.95±0.09	0.97±0.09	0.41
PBF* (%)	38.05 (33.67-40.75)	39 (35.12-42.25)	0.03**	38.1(33.55-41.05)	38.8(34.8-42.1)	0.13**
ABSI	0.01 ± 0.002	0.001 ± 0.002	0.75	0.0102±0.002	0.0098±0.002	0.35
AVI*	21.21(18.81-25.08)	22.89 (19.60-27.73)	0.02**	21.21(19.2-25.08)	23.32(19.30-28.44)	0.02**
Depression score*	5 (3-6)	9 (8-12)	0.001**	3(2-5)	9(7-12)	0.001**

BMI; Body Mass Index, WC; Waist Circumference, HC; Hip Circumference, WHR; Waist-hip ratio, PBF; percentage body fat, ABSI; A Body Shape Index, AVI; abdominal volume index

\*These variables are expressed as median and interquartile range and others are expressed as mean ± standard deviation

\*\* P -values were derived from Wilcoxon signed-rank and others from test independent *t* test

Table 4 show the logistic regression analysis used to examine the relationship between anthropometric indexes and depression or anxiety. Depression and anxiety had a significant positive relationship with WC, BF, WHR and AVI. Table 5 show that the BMI, WC, BF, BF% have a significant correlation with AVI (positively) and ABSI (negatively).

We set median of AVI as its cut off and, accordingly, we performed regression analysis for other measurements as described in Table 4. Even after adjustment for age and height being obese (BMI more than 30 kg/m<sup>2</sup>) had the greatest effects on AVI and smallest effect belonged to being at a BMI ranges 25 to 29.9 kg/m<sup>2</sup>.

**Table 4.** Logistic regression model predicting depression and anxiety according to anthropometric indices

Variables	Anxiety			Depression		
	OR	CI	P-V	OR	CI	P-V
Weight (kg)	1.019	(1.002-1.037)	0.03	1.020	(1.003-1.037)	0.01
Height (cm)	1.047	(1.000-1.097)	0.05	1.036	(1.007-1.047)	0.11
WC (cm)	1.028	(1.008-1.050)	0.007	1.027	(0.992-1.083)	0.01
HC (cm)	1.016	(0.989-1.043)	0.25	1.013	(1.007-1.047)	0.34
Anxiety	1.600	(1.428-1.792)	0.001	1.495	(1.363-1.640)	0.001
LBM (kg)	1.027	(0.993-1.063)	0.11	1.037	(1.003-1.072)	0.03
BF (kg)	1.033	(1.004-1.063)	0.02	1.029	(1.00-1.058)	0.04
PBF (%)	1.052	(0.993-1.113)	0.08	1.034	(0.980-1.092)	0.22
BMI (kg/m <sup>2</sup> )	1.038	(0.988-1.089)	0.13	1.043	(0.995-1.093)	0.08
WHR	119.284	(3.896-3652.5)	0.006	119.044	(4.315-328.54)	0.005
ABSI	0.000	(0.0-4.1E+33)	0.51	0.00	(0.00-3.593E+16)	0.19
AVI	1.063	(1.016-1.112)	0.009	1.061	(1.015-1.109)	0.01
Central obesity	1.577	(0.419-5.929)	0.50	0.891	(0.281-2.82)	0.84

BMI; Body Mass Index, WC; Waist Circumference, HC; Hip Circumference, WHR; Waist-hip ratio, LBM; Lean Body Mass, PBF; percentage body fat, ABSI; A Body Shape Index, AVI; abdominal volume index, CI; Confidence interval

P-Values were adjusted for age and gender

**Table 5.** Correlation markers for anthropometric measurements

Variables	PBF*		AVI*		ABSI	
	R	P-V	R	P-V	r	P-V
PBF	1	NA	0.42	<0.001	-0.47	<0.001
AVI	0.42	<0.001	1	NA	-0.64	<0.001
Height	-0.48	<0.001	0.20	<0.001	0.09	<0.001
Weight	0.28	0.001	0.77	<0.001	-0.80	<0.001
BMI	0.62	<0.001	0.80	<0.001	-0.90	<0.001
WC	0.43	<0.001	0.99	<0.001	-0.65	<0.001

PBF; percentage body fat, AVI; abdominal volume index, BMI; Body Mass Index, WC; Waist Circumference, ABSI; A Body Shape Index,

\* These correlation are obtained from Spearman test and others from Pearson test

## Discussion

There is a large body of literature assessing the interrelationship between obesity and mood disorders<sup>6,8,10</sup>. It has been suggested that there are a reciprocal link between depression /anxiety and obesity. A meta-analysis reported that obesity increased the risk of depression, and depression increased the odds for developing obesity<sup>23</sup>. On the other hand, there are various tools and indicators with different performance for assessing obesity. Recently, many studies have been conducted to introduce the best anthropometric measure predicting the relationship between obesity and mood disorder such as depression and anxiety.

In our study, we did not find any significant correlation between BMI and depression or anxiety. BMI is a conventional and easy tool for indication of overweight and obesity but it has some limitations include inability to differentiate the adipose tissue and lean body mass and also significant differences in the BMI efficiency between ethnic groups<sup>24,25</sup>. These limitations may be more in men due to higher muscle mass compare to women. Several studies reported that BMI was a significant predictor of depression in females but not in males<sup>26,27</sup>. It seems that other anthropometric indices are more effective to evaluate the relationship between obesity and depression/ anxiety status. Similar to our findings, Guedes et al suggested that the body fat percentage and not BMI was associated with an increased severity of anxiety and depressive symptoms based on HADS scores<sup>28</sup>.

Failing in indication of body shape by the BMI formed the basics of studies seeking new tools for locating body central fat including WC, ABSI and AVI. We hypothesized that new anthropometric indices including AVI and ABSI could be more useful because of the proposed ability to indicate abdominal fat accumulation. To the authors' knowledge this was the first investigation assessing the application of ABSI and AVI in clarification of relationship between obesity and depression or anxiety.

ABSI has obtained from standardization of WC to weight and height and proposed as a new index for estimation of death hazard due to obesity. High values of ABSI could imply that fat is over deposited in abdominal area and the fraction of lean body mass is diminished in periphery<sup>20</sup>. In comparison to normal subjects neither for depression nor for anxiety, we observed difference in mean ABSI.

Moreover ABSI had no significant correlation with BMI, BF, and BF% in our samples.

Our results also showed that AVI is higher in people with depression/anxiety. AVI takes place among the best indicators of abdominal fat deposition<sup>29</sup>. In consistent with the Ehrampoush et al. comparative study on various anthropometric tools for exploring adiposity we also suggest that AVI is strongly correlated with WC and BF which are predictive for accumulation of fat mass in central area of human body<sup>17</sup>. Abdominal adipose tissue induces immune system activation following release of cytokines and other regulatory molecules which in turn trigger inflammatory pathways in downstream<sup>30,31</sup>. Depression symptoms could be aggravated as a result of systemic inflammation so it has much of importance to concentrate on central adiposity when we are talking about the relationship between obesity and depression/anxiety<sup>32</sup>. Some other mechanisms have been suggested for the linkage between abdominal obesity and depression among them dysregulation of hypothalamic-pituitary-adrenocortical (HPA) axis resulted by reduction in glucocorticoid receptors (GR) and over secretion of cortisol could be emphasized<sup>33</sup>.

Our study had some limitations: The cross-sectional nature of this study made it difficult to conclude a causal relationship. Indeed it is not clearly understood whether depression or anxiety influenced the possibility of overweight and obesity or people with high amount of body fat appear with symptoms of depression or anxiety. Secondly, we could not find any correlation between ABSI and depression which could partly be due to small number of sample and confounders effect. Moreover it would be better if we had a control group with normal BMI to find a dose response for observed relationship between abdominal obesity and depression/anxiety. To the best of our knowledge, the study was the first to report the relationship between depression/anxiety and AVI and ABSI in among overweight and obese women.

## Conclusion

We concluded that AVI could be a better anthropometric measure for indication of relationship between abdominal obesity and depression/anxiety in a small population. The continuing increases in the global prevalence of overweight and obesity suggest that mental health sta-

tus should be screened and evaluated in obese individuals especially people with central obesity. A routine anthropometric index like BMI has some limitations to assess central obesity. Our results suggest that the AVI is useful for evaluating obesity in depression/anxiety.

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### Conflict of interests

The authors declare no conflict of interest.

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