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Association of new obesity markers with symptoms of depression: Analysis of a 4-year Peruvian national survey

Víctor Juan Vera-Ponce [a,*], Gianella Zulema Zeñas-Trujillo [a], Joan A. Loayza-Castro [a], Jamee Guerra Valencia [a,b], Fiorella E. Zuzunaga-Montoya [c], Mario J. Valladares-Garrido [d,e], Cori Raquel Iturregui Paucar [f], Jhony A. De La Cruz-Vargas [a]

[a] Instituto de Investigación en Ciencias Biomédicas de la Universidad Ricardo Palma, Peru
[b] Universidad Privada del Norte, Lima, Peru
[c] Universidad Científica del Sur, Lima, Peru
[d] Universidad Continental Lima, Peru
[e] Oficina de Epidemiología, Hospital Regional Lambayeque, Chiclayo. Peru
[f] Universidad Tecnológica del Perú, Lima, Peru

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ABSTRACT

Introduction: Although body mass index (BMI) and waist circumference (WC) are the most commonly used obesity markers in clinical practice regarding depression, some studies suggest that other obesity markers such as waist-to-height ratio (WHtR), a body shape index (ABSI), body roundness index (BRI), and conicity index (CI) may be more accurate in identifying patients with depression.
Objective: To determine the relationship between different markers of obesity and the presence of symptoms of depression.
Methods: Analytical cross-sectional study. A secondary analysis was conducted on the Demographic and Family Health Survey (ENDES) from 2018 to 2021. The main variable of the present study was the depression score. Numerical variables were presented as mean and confidence interval at 95 % (CI 95 %). A generalized linear model of the Gaussian family and Identity link function was performed to evaluate the strength of association between the variables of interest.
Results: The average depression score in the study population was 2.61 (95 % CI 2.56–2.65). In the multivariable analysis, the depression score increased for each unit that increased the BMI by 0.011 points (β = 0.011; 95 % CI 0.002–0.020), the WHtR by 0.207 points (β = 0.207; 95 % CI 0.145–0.267), the ABSI by 0.158 points (β = 0.158; IC95% 0.047–0.269), the BRI by 0.096 points (β = 0.096; IC95% 0.069–0.122), and the CI by 0.010 points (β = 0.010; IC95% 0.004–0.016). There was no statistically significant association for WC.
Conclusions: The WHtR may be a better marker of obesity for identifying patients with depressive symptoms compared to other markers.

1. Introduction

Obesity is a significant global health issue that affects a large number of people (Apovian, 2016). According to the World Health Organization (WHO), in 2016, >1.9 billion adults worldwide were overweight, of which over 650 million were patients with obesity (Obesidad y sobrepeso, 2023). Obesity has been linked to numerous health problems, including cardiovascular diseases, type 2 diabetes, some types of cancer, and musculoskeletal disorders (Blüher, 2019). In addition, obesity has also been associated with an increased risk of depression (Jantaratnotai et al., 2017; Wang et al., 2022).

It is estimated that 6.97 % of patients with obesity have depression (Vera-Ponce et al., 2023). The presence of depression can also have a significant impact on the treatment of obesity, as patients with this condition may have difficulties in losing weight and maintaining a healthy lifestyle (Patsalos et al., 2021; Rao et al., 2020).

* Corresponding author at: Universidad Ricardo Palma, Lima, Peru.
E-mail addresses: victor.vera@urp.edu.pe (V.J. Vera-Ponce), mvalladares@continental.edu.pe (M.J. Valladares-Garrido), jhony.delacruz@urp.edu.pe (J.A. De La Cruz-Vargas).

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Though Body Mass Index (BMI) and Waist Circumference (WC) are most frequently used in clinical practice as markers of obesity when considering depression (Malmir et al., 2019; Zhao et al., 2011), other obesity indicators such as Waist-to-Height Ratio (WHtR) (Wiltink et al., 2013; Ma et al., 2021), A Body Shape Index (ABSI), Body Roundness Index (BRI), and Conicity Index (CI) may offer a more precise identification of patients with depression (Lotfi et al., 2022; Hadi et al., 2020). These markers give a more accurate representation of the distribution of body fat, which is intrinsically tied to the risk of metabolic and cardiovascular diseases (Bertoli et al., 2017; Calderón-García et al., 2021; Stefanescu et al., 2020). In the context of depression, these obesity markers are especially relevant because they are linked to the physiological and metabolic changes associated with depressive symptoms. Research has shown that alterations in body composition and increased central adiposity, as indicated by these obesity markers, can affect neuroendocrine regulation and inflammatory processes, which in turn can influence mood regulation and contribute to the development and severity of depressive symptoms (Chrzastek et al., 2021). Thus, these obesity markers could not only play a pivotal role in diagnosing depression but also in understanding its pathophysiology.

Considering everything mentioned above, our study aimed to determine the relationship between different markers of obesity and the presence of symptoms of depression, to improve the prevention, diagnosis, and treatment of both health issues.

2. Materials and methods

2.1. Study design

Analytical cross-sectional study. A secondary analysis was conducted on the Demographic and Family Health Survey (ENDES) from 2018 to 2021. The STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology) were followed for the present study.

2.2. Population and sample

ENDES is a national survey conducted by the National Institute of Statistics and Informatics (INEI) using a probabilistic, two-stage, stratified, and independent sampling method at the departmental and urban and rural zone levels in Peru. The survey provides information on fertility, mortality, maternal and child health, and communicable and non-communicable diseases in the country. ENDES consists of three questionnaires: 1) household questionnaire, 2) individual women's questionnaire, and 3) health questionnaire. The health questionnaire gathers information on non-communicable diseases, including mental health.

For our study, patients under the age of 18 were excluded, as were those with missing values in the main variables.

2.3. Variables

The main variable of the present study was the depression score. This measures the presence of depressive symptoms, through the Patient Health Questionnaire-9 (PHQ-9). This questionnaire is a tool used to screen for depression and has been validated in Peru (Alvarez et al., 2022).

The PQH-9 instrument consists of nine questions that assess the presence of depressive symptoms. Responses to these questions measure the severity of symptoms on a scale of 0 (never) to 3 (almost every day), resulting in a total score ranging from 0 to 27 points.

Exposure variables

Waist Circumference (WC)

$$\text{Body Mass Index (BMI)} = \text{Weight (Kg)}/\text{Height}^2 \text{ (meters)}$$

$$\text{Waist} - \text{to} - \text{height ratio (WHtR)} = \text{WC}/\text{Height}$$

Table 1
Descriptive analysis of the characteristics of the study population.

Characteristics	Total
	n (%weighted)
Sex	
Male	57,280 (53.47)
Female	49,846 (46.53)
Age groups	
18 to 35 years old	39,235 (36.62)
35 to 60 years old	46,487 (43.39)
60 to 69 years old	11,535 (10.77)
70 years old or more	9869 (9.21)
Year	
2018	21,204 (19.79)
2019	32,023 (29.89)
2020	21,857 (20.40)
2021	32,041 (29.91)
Civil status	
Single	18,518 (17.29)
Married	30,606 (28.57)
Cohabitant	38,510 (35.95)
Widower	6919 (6.46)
Divorced	1006 (0.94)
Separated	11,567 (10.80)
Natural region	
Metropolitan Lima	40,135 (37.47)
Rest of coast	27,645 (25.81)
Mountains	26,306 (24.56)
Jungle	12,041 (12.17)
Education level	
No level	237 (0.23)
Primary	21,685 (21.06)
Secondary	44,212 (42.93)
Higher	36,852 (35.78)
Wealth index	
the poorest	19,641 (18.33)
Poor	21,648 (20.21)
medium	22,218 (20.74)
Rich	21,776 (20.33)
Richest	21,841 (20.39)
Residence area	
Urban	86,456 (80.70)
Rural	20,670 (19.30)
Physical disability	
No	104,315 (97.38)
Yes	2810 (2.62)
Smoke daily	
No	105,319 (98.31)
Yes	1807 (1.69)
Alcohol consumption	
No	93,521 (87.34)
Yes	13,544 (12.66)
History of hypertension	
No	95,391 (89.12)
Yes	11,645 (10.88)
History of T2DM	
No	102,090 (95.35)
Yes	4878 (4.65)

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Table 1 (*continued*)

Characteristics	Total
	n (%weighted)
Depression score[a]	2.61 (2.56–2.65)
BMI (Kg/m2)[a]	27 0.51 (27.47–27.57)
WC (cm)[a]	93.37 (93.23–93.50)
WHtR[a]	0.591 (0.590–0.592)
ABSI[a]	0.081 (0.080–0.082)
BRI[a]	5.35 (5.33–5.37)

Source: self-made.
[a] mean (confidence interval at 95 %).

$$\text{A Body Shape Index (ABSI)} = \frac{WC}{BMI^{2/3} * Height^{1/2.}}$$

$$\text{Body Roundness Index (BRI)} = 364,2 - 365,5 * \sqrt{1 - \frac{\left(\frac{WC}{2\pi}\right)^2}{(0.5 * Weight)^2}}$$

$$\text{Conicity Index (COI)} = \frac{WC}{0,109 * \sqrt{\frac{Weight\ (kg)}{Height(m)}}}$$

The study covariates were: sex (female and male), age groups (18–25, 35–59, 60–69, and 70 or older), year (2018, 2019, 2020, and 2021), marital status (single, married, cohabiting, widowed, divorced, and separated), region (Metropolitan Lima, coastal, Andean, and jungle), education (no education, primary, secondary, and higher), wealth index (poorest, poor, middle, rich, and richest), area of residence (urban vs rural), physical disability (no vs yes), daily smoking (no vs yes), alcohol consumption (no vs yes), history of hypertension (no vs yes), and history of type 2 diabetes mellitus (T2DM) (no vs yes).

2.4. Statistical analysis

The statistical software program STATA v.17 (Stata Corporation, College Station, Texas, USA) was utilized for data analysis. Sociodemographic characteristics were reported using absolute frequencies, while numerical variables were presented as mean and confidence interval at 95 % (CI 95 %). The Student's *t*-test was utilized to compare means of continuous variables across different categories in the bivariate analysis, whereas the Pearson correlation test was employed for obesity markers. A statistically significant value was considered <0.05 ($p < 0.05$) for the statistical tests.

A generalized linear model of the Gaussian family and Identity link function was performed to evaluate the strength of association between the variables of interest. The adjusted beta coefficient was obtained by adjusting for variables such as sex, age groups, year, civil status, residence area, physical disability, natural region, educational level, wealth index, daily smoking, alcohol consumption, history of hypertension, and history of Type 2 diabetes mellitus (T2DM). All computed estimates considered the complexity of the sample, including the sample strata, primary sampling units, and population weights, applying SVY commands. We employed appropriate methods to estimate results within specific subpopulations.

2.5. Ethical considerations

This study was based on the analysis of publicly available survey datasets that are freely available online with all identifier information removed. All downloaded data was submitted anonymously, so the potential harm to primary study participants was minimal.

3. Results

The average depression score in the study population was 2.61 (95 %

Table 2
Bivariate characteristics of the factors associated with the depression score.

Characteristics	Depression score	p value[a]
	Mean ± CI 95 %	
Sex		
Male	1.93 (1.88–1.98)	<0.001
Female	3.38 (3.31–3.45)	
Age groups		
18 to 35 years old	2.15 (2.09–2.20)	<0.001
35 to 60 years old	2.51 (2.45–2.57)	
60 to 69 years old	3.20 (3.08–3.34)	
70 years old or more	4.16 (3.98–4.34)	
Year		
2018	2.43 (2.34–2.53)	<0.001
2019	2.57 (2.49–2.65)	
2020	2.67 (2.58–2.76)	
2021	2.71 (2.63–2.79)	
Civil status		
Single	2.36 (2.26–2.45)	0.002
Married	2.55 (2.47–2.63)	
Cohabitant	2.17 (2.11–2.22)	
Widower	4.50 (4.28–4.70)	
Divorced	2.82 (2.29–3.36)	
Separated	3.45 (3.31–3.59)	
Natural region		
Metropolitan Lima	2.42 (2.34–2.51)	<0.001
Rest of coast	2.25 (2.18–2.31)	
Mountains	3.39 (3.31–3.47)	
Jungle	2.34 (2.26–2.42)	
Education level		
No level	5.46 (4.41–6.50)	<0.001
Primary	3.39 (2.29–3.49)	
Secondary	2.49 (2.42–2.55)	
higher	2.01 (1.94–2.07)	
Wealth index		
The poorest	3.14 (3.06–3.23)	<0.001
Poor	2.67 (2.59–2.75)	
Medium	2.62 (2.53–2.70)	
Rich	2.48 (2.39–2.57)	
Richest	2.16 (2.05–2.26)	
Residence area		
Urban	2.49 (2.47–2.54)	<0.001
Rural	3.07 (2.99–3.15)	
Physical disability		
No	2.54 (2.50–2.58)	<0.001
Yes	5.17 (4.79–5.55)	
Smoke daily		
No	2.61 (2.57–2.65)	0.312
Yes	2.44 (2.12–2.76)	
Alcohol consumption		
No	2.66 (2.62–2.71)	<0.001
Yes	2.21 (2.11–2.32)	
History of hypertension		
No	2.42 (2.38–2.46)	<0.001
Yes	4.11 (3.95–4.27)	
History of T2DM		
No	2.52 (2.49–2.57)	<0.001
Yes	4.15 (3.90–4.39)	

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Table 2 (*continued*)

Characteristics	Depression score	p value[a]
	Mean ± CI 95 %	
BMI (Kg/m2)[b]	−0.012	<0.001
WC (cm)[b]	−0.016	<0.001
WHtR[b]	0.089	<0.001
ABSI[b]	0.067	<0.001
BRI[b]	0.072	<0.001

[a] Analysis performed with the student's *t*-test.
[b] Analysis performed with the Pearson correlation test.

CI 2.56–2.65). The female sex accounted for 46.53 % of the population. The older adult population accounted for 19.98 %. The number of residents in rural areas was 19.30 %. Regarding the presence of comorbidities, 10.88 % and 4.65 % had a history of hypertension and T2DM, respectively (Tables 1 and 2).

In the bivariate analysis, no association was found between daily smoking and the depression score ($p = 0.312$). In the correlation analysis, a negative association was found between BMI and WC, while this was positive for WHtR, ABSI, LBBB and CI (all with $p < 0.001$ value).

For BMI, the depression score increases by 0.011 points ($\beta = 0.011$; 95 % CI 0.002–0.020). For Waist-to-Height Ratio (WHtR), the depression score increases by 0.207 points ($\beta = 0.207$; 95 % CI 0.145–0.267). For A Body Shape Index (ABSI), the depression score increases by 0.158 points ($\beta = 0.158$; IC95% 0.047–0.269). In the case of BRI, the depression score increases by 0.096 points ($\beta = 0.096$; IC95% 0.069–0.122). Finally, for CI, the depression score increases by 0.010 points ($\beta = 0.010$; IC95% 0.004–0.016). However, we did not find a statistically significant association between Waist Circumference (WC) and the depression score. These findings are summarized in Table 3.

4. Discussion

Our study found evidence of a relationship between the presence of depression symptoms and different anthropometric indicators of obesity, however, the magnitude and direction of the relationship varied depending on the indicator used. The association was strongest for WHtR, followed by ABSI and BRI, and was very low for BMI and CI. There was no association with WC.

Regarding classical markers of obesity, in our study, WHtR, followed by BMI, performed better than WC. In the study by Wiltink et al. (2013), after adjusting for potential confounding factors in adults aged 35–75 years, associations were found between the presence of depressive symptoms and obesity measures such as BMI and WHtR, but not with WC. Similarly, Ma et al. (2021) found a significant U-shaped relationship between BMI, WHtR, and depression. The study by Ho et al. (2008) also did not find an association with WC. However, the study by Zedler et al. (2014) in postmenopausal women found that WC had a stronger association with depression than the other two markers. It is likely that BMI had a stronger association with depression than waist circumference because the patient sample included had a more homogenous distribution of body fat in relation to WC (Goossens, 2017). However, it is important to note that BMI does not provide information about body fat distribution.

In addition to those mentioned in the previous paragraph, other research studies such as Chrzastek et al. (2021), in the elderly population, highlighted the role of WHtR as the best indicator of depression in our study. The reasons behind this could be attributed to the fact that WHtR takes into account both waist and height, providing a more precise measure of the distribution of body fat, specifically intraorgan fat. The accumulation of intraorgan fat has been associated with a higher risk of health problems such as cardiovascular disease, type 2 diabetes, metabolic syndrome (Apovian, 2016; A et al., 2017), and a higher risk of depression and anxiety disorders (Patsalos et al., 2021; Rao et al., 2020).

Few studies have examined the relationship between new obesity markers and depression. Lotfi et al. (2022) found that ABSI was associated with depression among women, but not men, while no relationship was found with BRI. Hadi et al. (2020) found that ABSI had no significant correlation with depression, unlike WC.

ABSI, BRI, and CI are obesity markers that take into account the ratio of waist circumference to height, and the ratio of height to weight, respectively. These measures may provide a more accurate assessment of fat distribution in these critical areas, which may make them more strongly associated with depression than waist circumference alone (Bertoli et al., 2017; Calderón-García et al., 2021; Stefanescu et al., 2020). In addition, it has been shown that fat accumulation in certain areas of the body, such as the abdomen and hips, can impact mental health, including depression (Olive et al., 2017; Giovannini et al., 2019). No studies have evaluated CI and depression.

There are some limitations to note. Firstly, because this is a cross-sectional study, causality cannot be determined, and longitudinal studies would be needed to evaluate this relationship. Secondly, depression itself was not directly evaluated; rather, the presence of depressive symptoms was assessed. Also, it's important to note that although these obesity markers demonstrated a statistical association with depression scores, the clinical significance of these findings requires further investigation. It's recognized that the effect sizes observed in this study are small, and the implications for clinical practice have yet to be fully determined. Nevertheless, this study has the strength of using a nationally representative population and providing a first expression of the magnitude of the problem and the probable associated factors in the Peruvian population.

5. Conclusion

The WHtR may be a better marker of obesity for identifying patients with depressive symptoms compared to other markers. The importance of identifying WHtR as a good indicator of depression lies in its simple and inexpensive calculation. If future studies confirm its relationship

Table 3
Multivariable simple and adjusted regression analysis of the association between obesity markers and depression score.

Characteristics	Crude analysis			Adjusted analysis[a]		
	Coeff. Beta crude	CI 95 %	p**	Coeff. Beta adjusted	CI 95 %	p**
BMI (Kg/m2)	0.005	−0.004–0.014	0.284	0.011	0.002–0.020	0.023
WC (cm)	−0.001	−0.005–0.002	0.591	−0.001	−0.005–0.002	0.591
WHtR (×10)	0.399	0.343–0.454	<0.001	0.207	0.145–0.267	<0.001
ABSI (×100)	0.816	0.711–0.920	<0.001	0.158	0.047–0.269	0.005
BRI	0.182	0.157–0.207	<0.001	0.096	0.069–0.122	0.001
CI	0.040	0.034–0.045	<0.001	0.010	0.004–0.016	0.001

CI 95 %: confidence interval at 95 %.
Source: self-made.
[a] Adjusted for sex, age groups, year, civil status, Residence area, Physical disability, natural region, educational level, wealth index, daily smoking, alcohol consumption, history of hypertension, history of T2DM.
** p-value significant <0.05.

with depression, it may have important clinical implications, as WHtR can be used as an early indicator of depression risk in patients with obesity. This would enable early intervention in the management of both conditions and improve the quality of life of patients.

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CRediT authorship contribution statement

The authors participated in the genesis of the idea, project design, data collection and interpretation, analysis of results, and preparation of the manuscript of this research paper.

Declaration of competing interest

The authors declare no conflict of interest.

Data availability

Data will be made available on request.

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