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Sex differences in the relationship between whole-body and region-specific fat mass indices and anxiety symptoms in South Korean adults

Seong-Uk Baek and Jin-Ha Yoon

Background

Although a relationship between body fat and mental health problems has been established, sex-based differences in this association remain insufficiently understood.

Aims

To investigate the association of whole-body and regional fat mass indices with anxiety symptoms in men and women.

Method

A nationwide sample of 3856 men and 5010 women was analysed. Fat mass of the whole body, trunk, arm and leg was measured using a bioelectrical impedance analyser, and fat mass indices (kg/m^2) were derived by dividing fat mass by height squared. Symptoms of anxiety were determined using the Generalized Anxiety Disorder-7. Logistic regressions were used to investigate the association of each fat mass index with anxiety symptoms. Sex-stratified analyses were conducted to assess sex-related differences.

Results

The prevalence of anxiety symptoms was 3.3% among men and 5.5% among women. Among female participants, a one-standard deviation increase in whole-body, trunk, arm or leg fat mass index was associated with 1.20-fold (95% CI: 1.04–1.39), 1.21-fold (95% CI: 1.04–1.41), 1.19-fold (95% CI: 1.04–1.35) and 1.19-fold (95% CI: 1.03–1.38) increases in odds of anxiety symptoms, respectively. By contrast, no clear association was observed between fat mass indices and anxiety symptoms in men.

Conclusions

Our analysis demonstrated sex differences in the relationship between body fat and anxiety, with high whole-body and regional fat mass indices positively associated with anxiety symptoms in women.

Keywords

Anxiety; bioimpedance analysis; body composition; mental health; obesity.

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Obesity is a major public health concern with a global prevalence that has increased steadily over the past decade.[1] In South Korea, obesity has been defined as a body mass index (BMI) $\geq$ 25 kg/m^2 according to the World Health Organization criteria for the Western Pacific Region and the guidelines of the Korean Society for the Study of Obesity.[2] South Korea has witnessed a steady increase in obesity rates, which have reached approximately 38.4% in men and 27.8% in women.[3] Although BMI has traditionally been used to classify obesity, clinical practitioners and researchers now emphasise the use of direct body fat mass measurements such as dual-energy X-ray absorptiometry (DEXA) or bioelectrical impedance analysis (BIA), because BMI may not adequately reflect actual adiposity.[4]

Studies have examined the relation between obesity and mental health. A systematic review has revealed that obesity is linked to both depression and suicidal behaviours.[5,6] Although relatively few studies have investigated the relation between obesity and anxiety symptoms, some have shown that individuals with obesity have a high risk of anxiety symptoms.[7,8] The relation between obesity and mental health problems is bidirectional: excess body fat can cause deterioration of mental health, which may in turn lead to changes in body fat through poor health behaviours.[9] Although the precise mechanisms linking adiposity and mental health problems have not been fully elucidated, it has been suggested that both biological and psychosocial mechanisms contribute to systemic inflammation and weight-related social stigma.[10–12]

Despite studies demonstrating a strong relationship between obesity and mental health problems, several gaps remain in the literature. First, most studies used BMI, with limited numbers of studies directly measuring fat mass using methods such as DEXA or BIA. Although recent studies have found a positive association between directly measured fat mass and depressive symptoms,[13,14] there has been little exploration of any specific link with anxiety symptoms. Second, sex differences are an important aspect to consider when examining the relationship between body fat mass and mental health problems,[15,16] and studies have produced mixed findings in this regard. For instance, some studies have reported that fat mass measured using DEXA or BIA is positively associated with depressive symptoms among women but not men,[16,17] whereas another study found that the associations of body fat percentage with depression were more pronounced in men than in women.[14] Significant sex-based differences in the distribution and physiology of body fat are well documented, and societal attitudes towards body image also differ markedly by sex; both of these factors may contribute to potential sex-specific relationships between body fat and mental health problems.[18] However, to the best of our knowledge, sex differences in the association of body fat mass with anxiety symptoms have not yet been investigated according to the existing literature. Therefore, in this study, we aimed to explore sex-based differences in the association of body fat mass indices with anxiety symptoms among South Korean adults.

Method

Study participants

Samples from the 2022 and 2023 South Korea National Health and Nutrition Examination Survey (KNHANES) were included in this study. The KNHANES is an annual cross-sectional survey intended

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to collect information on the health status of people living in South Korea. Participants were invited using a multistage clustered probability sampling procedure to achieve a nationally representative sample. For the selected participants, a face-to-face survey was administered during a household visit by researchers from the Korea Disease Control and Prevention Agency (KDCA) in mobile examination vehicles. Detailed information on the sampling procedure, survey methodology and quality control can be found in the data profile article. The raw data were anonymised by researchers at the KDCA and are accessible at https://knhanes.kdca.go.kr. The 2022 and 2023 KNHANES were implemented following approval from the Institutional Review Board of the KDCA (2018-01-03-4C-A, 2022-11-16-R-A).

A diagram depicting the sample selection procedure is shown in Supplementary Fig. 1 available at https://doi.org/10.1192/bjo.2026.12063. Initially, 11 229 adults aged >18 years from the 2022 and 2023 survey years of the KNHANES were included. Individuals who did not undergo BIA, such as pregnant women, those with pacemakers or those with prosthetic limbs, were excluded from the study ($n = 816$). After exclusion of participants with missing values ($n = 1547$), 8866 individuals (3856 men and 5010 women) were included in our sample.

Body fat mass indices

BIA was performed using a bioelectrical impedance analyser (InBody 970, Biospace, South Korea) in accordance with a standardised protocol. The participants were fasted, and they stood upright with their arms extended and gripped the electrodes with both hands. For quality control, examiners received training twice a year, and onsite quality assessments and equipment maintenance were also conducted twice a year to ensure proper BIA performance. In the South Korean population, the bioelectrical impedance analyser (InBody 970, Biospace, South Korea) has shown criterion validity for measurement of both whole-body and regional fat mass, with a strong correlation ($R^2 = 0.929$) for percentage body fat compared with measurements obtained using DEXA.[19] The body fat indices used in this study included whole-body, trunk, arm (bilateral) and leg (bilateral) fat. Fat mass indices were calculated by dividing each fat mass by height squared (kg/m^2). In addition, body fat percentage was derived by dividing the whole-body fat mass by total body weight.

Anxiety

The Generalized Anxiety Disorder-7 (GAD-7), a screening questionnaire to assess anxiety symptoms that has been validated in the South Korean population,[20,21] was used in this study. The GAD-7 includes seven items, with each item scored on a scale of zero to three. The range of the total GAD-7 score is 0–21, and individuals with a score ≥10 were classified as having anxiety symptoms.[20] Cronbach's alpha was 0.89 in this study, indicating good reliability.

Confounders

The following sociodemographic characteristics were included: age (continuous scale), educational level (middle school or below, high school, or college or above), income (lowest, low, high or highest), employment status (worker or unemployed), marital status (married, unmarried or other), physical activity (no or yes), smoking status (no or yes), alcohol use (no or yes) and survey year (2022 or 2023). Income levels were categorised into four groups using quartile values of the distribution of individuals' monthly net income among the sample. Physical activity was assessed using the Global Physical Activity Questionnaire and classified as 'yes' if individuals participated in ≥150 min per week of moderate-to-vigorous exercise. Alcohol use was categorised as 'yes' if individuals consumed alcohol at least once a month.

Statistical analysis

Sample characteristics were examined on the basis of the presence of anxiety symptoms. In addition, the distributions of body fat mass indices and body fat percentages among those with and without anxiety symptoms were examined using a density plot. For the main analyses, we investigated the associations between body fat mass indices and body fat percentage and anxiety symptoms using logistic regressions; the change in odds of experiencing anxiety symptoms per standard deviation increase was estimated for each index, and both unadjusted and adjusted models were fitted. To explore sex-based differences, we included interaction terms between sex and each index (sex × index) in the regression models, and the corresponding *P*-values were calculated. In addition, models were stratified by sex to examine whether the associations manifested differently according to participants' sex. In addition to odds ratios, average marginal effects that corresponded to the mean probability differences were determined using R package 'margins'.[22] Finally, to examine the nonlinear relation between each index and anxiety symptoms, we used the restricted cubic spline function[23] and visualised the results using the 'ggplot2' R package. Statistical analyses were performed using R software for Windows (version 4.4.1; R Foundation for Statistical Computing, Vienna, Austria; https://www.r-project.org). The 'survey' R package was used to reflect the complex survey design.[24] Model fit statistics (Akaike information criterion, Bayesian information criterion and pseudo-R^2) were used to compare models across fat mass indices. We also calculated *P*-values adjusted by false discovery rate to address multiple testing across five adiposity indices. Previous studies of South Korean adults have recommended a cut-off of GAD-7 score > 6 for classification of anxiety;[25,26] therefore, this alternative cut-off was used in the sensitivity analysis. In models mutually adjusting for body fat mass indices with either BMI or waist circumference, substantial multicollinearity was observed (variance inflation factor > 5); therefore, the results of these models are not presented.

Ethics statement

The 2022 and 2023 KNHANES were implemented following approval from the Institutional Review Board of the Institutional Review Board of the KDCA (2018-01-03-4C-A, 2022-11-16-R-A). All participants provided written informed consent. We assert that procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation, and with the Helsinki Declaration of 1975 as revised in 2013.

Results

The prevalence of anxiety symptoms was 3.3% among men and 5.5% among women (Table 1). Those with anxiety symptoms were more likely to be younger, to have a lower income level, to be unemployed and to be current smokers than those without anxiety symptoms in both groups.

Figure 1 presents density plots comparing the distributions of fat mass indices and body fat percentages between individuals with and without anxiety symptoms. Although the distributions of fat mass indices and body fat percentage largely overlapped among men, the distribution of body fat indices tended to shift slightly to

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Table 1 Distribution of characteristics among participants

	Men ($n = 3856$)		Women ($n = 5010$)	
	Anxiety symptoms		Anxiety symptoms	
	Yes	No	Yes	No
Characteristic	126 (3.3%)	3730 (96.7%)	276 (5.5%)	4734 (94.5%)
Age, years, mean (s.d.)	48.7 (17.6)	52.9 (17.1)	48.3 (18.1)	52.8 (16.2)
Education level, *n* (%)				
Middle school or below	19 (15.1)	775 (20.8)	77 (27.9)	1298 (27.4)
High school	46 (36.5)	1288 (34.5)	96 (34.8)	1585 (33.5)
College or above	61 (48.4)	1667 (44.7)	103 (37.3)	1851 (39.1)
Income level, *n* (%)				
Lowest	35 (27.8)	893 (23.9)	91 (33.0)	1124 (23.7)
Low	35 (27.8)	926 (24.8)	58 (21.0)	1184 (25.0)
High	29 (23.0)	959 (25.7)	66 (23.9)	1217 (25.7)
Highest	27 (21.4)	952 (25.5)	61 (22.1)	1209 (25.5)
Employment status, *n* (%)				
Worker	85 (67.5)	2663 (71.4)	147 (53.3)	2662 (56.2)
Unemployed	41 (32.5)	1067 (28.6)	129 (46.7)	2072 (43.8)
Marital status, *n* (%)				
Married	74 (58.7)	2586 (69.3)	134 (48.6)	3098 (65.4)
Unmarried or other	52 (41.3)	1144 (30.7)	142 (51.4)	1636 (34.6)
Physical activity, *n* (%)				
No	62 (49.2)	1889 (50.6)	150 (54.3)	2602 (55.0)
Yes	64 (50.8)	1841 (49.4)	126 (45.7)	2132 (45.0)
Current smoking status, *n* (%)				
No	80 (63.5)	2639 (70.8)	244 (88.4)	4530 (95.7)
Yes	46 (36.5)	1091 (29.2)	32 (11.6)	204 (4.3)
Alcohol use, *n* (%)				
No	47 (37.3)	1255 (33.6)	148 (53.6)	2827 (59.7)
Yes	79 (62.7)	2475 (66.4)	128 (46.4)	1907 (40.3)
Whole-body fat mass index, kg/m^2, mean (s.d.)	6.2 (2.4)	6.3 (2.2)	8.5 (3.3)	8.0 (2.6)
Trunk fat mass index, kg/m^2, mean (s.d.)	3.2 (1.3)	3.3 (1.3)	4.3 (1.7)	4.0 (1.4)
Arm fat mass index, kg/m^2, mean (s.d.)	0.8 (0.5)	0.8 (0.4)	1.3 (0.7)	1.2 (0.5)
Leg fat mass index, kg/m^2, mean (s.d.)	1.8 (0.6)	1.8 (0.5)	2.5 (0.8)	2.4 (0.7)
Body fat percentage (%), mean (s.d.)	24.6 (6.2)	24.8 (5.8)	34.3 (6.7)	33.1 (6.1)

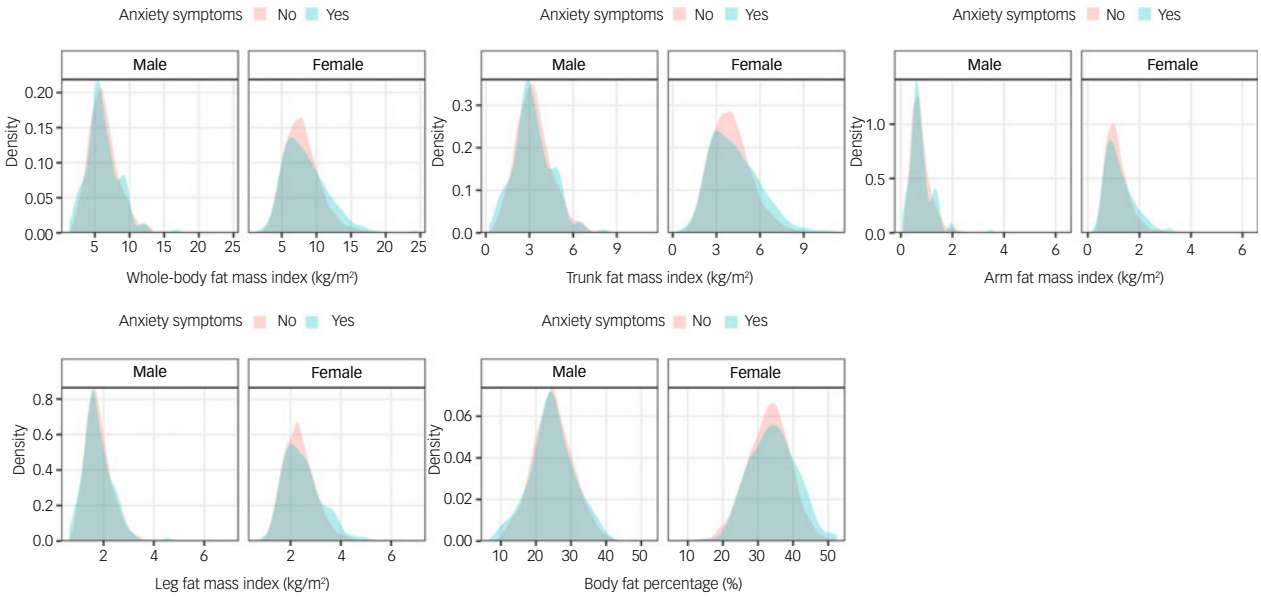


Fig. 1 Distribution of adiposity indices among individuals with and without anxiety symptoms.

the right among women with anxiety symptoms compared with women without such symptoms.

Table 2 shows associations among fat mass indices, body fat percentage and anxiety symptoms in men and women. No clear associations of body fat mass indices or body fat percentage with anxiety symptoms were identified in either the unadjusted or fully adjusted models among men. Among women, in the adjusted model, the odds ratios (95% CIs) for the association of a

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Table 2 Associations among body fat mass indices, body fat percentage and anxiety symptoms among men and women

Index[a]	Model 1[b]				Model 2[c]			
	Odds ratio (95% CI)	Average marginal effect (95% CI)	*P*-value	*P*-value[d]	Odds ratio (95% CI)	Average marginal effect (95% CI)	*P*-value	*P*-value[d]
Male								
Whole-body fat mass index	0.92 (0.74–1.15)	−0.002 (−0.010, 0.005)	0.469	0.661	0.91 (0.74–1.12)	−0.003 (−0.010, 0.004)	0.373	0.533
Trunk fat mass index	0.91 (0.74–1.13)	−0.003 (−0.010, 0.004)	0.409	0.661	0.90 (0.74–1.11)	−0.003 (−0.010, 0.004)	0.330	0.533
Arm fat mass index	0.95 (0.76–1.18)	−0.002 (−0.010, 0.006)	0.625	0.661	0.93 (0.76–1.14)	−0.002 (−0.009, 0.005)	0.486	0.580
Leg fat mass index	0.95 (0.74–1.20)	−0.002 (−0.010, 0.006)	0.647	0.661	0.93 (0.75–1.16)	−0.002 (−0.010, 0.005)	0.522	0.580
Body fat percentage	0.95 (0.73–1.22)	−0.002 (−0.010, 0.007)	0.661	0.661	0.95 (0.75–1.20)	−0.002 (−0.009, 0.006)	0.683	0.683
Female								
Whole-body fat mass index	1.20 (1.03–1.40)	0.010 (0.001, 0.019)	0.021	0.064	1.20 (1.04–1.39)	0.010 (0.001, 0.017)	0.014	0.042
Trunk fat mass index	1.19 (1.02–1.39)	0.009 (0.001, 0.018)	0.032	0.064	1.21 (1.04–1.41)	0.010 (0.001, 0.018)	0.015	0.042
Arm fat mass index	1.21 (1.06–1.39)	0.010 (0.003, 0.018)	0.004	0.064	1.19 (1.04–1.35)	0.009 (0.002, 0.016)	0.009	0.042
Leg fat mass index	1.21 (1.03–1.41)	0.010 (0.001, 0.019)	0.018	0.064	1.19 (1.03–1.38)	0.009 (0.001, 0.017)	0.021	0.042
Body fat percentage	1.25 (1.02–1.53)	0.012 (0.001, 0.023)	0.031	0.064	1.28 (1.04–1.57)	0.013 (0.001, 0.024)	0.019	0.042

a. Units were defined as a one-standard deviation increase for each index.
b. Unadjusted model.
c. Adjusted for age, education, income, employment status, marital status, smoking status, physical activity, alcohol use and survey year.
d. *P*-values adjusted by false discovery rate.

one-standard-deviation increase in each body fat index with anxiety symptoms were 1.20 (1.04–1.39) for whole-body fat mass index ($P = 0.014$), 1.21 (1.04–1.41) for trunk fat mass index ($P = 0.015$), 1.19 (1.04–1.35) for arm fat mass index ($P = 0.009$), 1.19 (1.03–1.38) for leg fat mass index ($P = 0.021$) and 1.28 (1.04–1.57) for body fat percentage ($P = 0.019$). When model fit statistics were compared across various body fat mass indices among female participants (Supplementary Table 1), the model including the arm fat mass index exhibited the lowest Akaike information criterion (2104.445) and Bayesian information criterion (2186.674) values and the highest pseudo-R^2 (0.06).

Supplementary Table 2 shows the *P*-values for the sex-based interactions between each body fat index and anxiety symptoms; these were 0.025, 0.020, 0.029, 0.057 and 0.065 for whole-body fat mass index, trunk fat mass index, arm fat mass index, leg fat mass index and body fat percentage, respectively. Supplementary Table 3 shows the results of sensitivity analyses based on the imputed datasets, in which the associations of body fat index with anxiety symptoms were consistent with those identified in the primary analyses. The results using the alternative GAD-7 cut-off produced similar findings that were comparable with those of the main analyses and supported positive associations between fat mass indices and anxiety among women (Supplementary Table 4).

Figure 2 illustrates the nonlinear relationships of body fat mass indices and body fat percentage with the predicted probability of anxiety symptoms. Among men, no clear positive associations were observed, and a slight decreasing trend was noted across the body fat mass indices. By contrast, among women, increasing fat mass indices and body fat percentages were associated with an increasing trend in the probability of anxiety symptoms.

Discussion

This study explored sex differences in the associations of body fat mass indices and body fat percentage with anxiety symptoms in South Korean adults. The findings indicate that both whole-body and regional body fat mass indices are positively associated with anxiety symptoms in women. By contrast, no clear associations were observed in men.

The results of this study corroborate previous findings showing that body fat mass indices are positively associated with poor mental health.[13,14] Building upon previous research that has identified a positive association between obesity and anxiety,[7,8] our study contributes to the literature by demonstrating a potential link between fat mass, measured via BIA, and anxiety, especially in women. Inconsistent findings regarding sex-based differences in the association between body fat and mental health problems have been reported. For instance, a study of UK adults showed that body fat percentage was positively correlated with risk of depression during follow-up among women, but there was no clear association among men.[16] In addition, whole-body and regional body fat mass measured using DEXA have been found to be positively associated with depression, especially among women.[17] By contrast, another study reported that the link between body fat mass and depressive symptoms was more pronounced in men than in women.[14] Unlike previous studies that were predominantly conducted in Western populations, the present study was based on an Asian population. Considering sociocultural context and ethnic variability with respect to body image and body fat characteristics, our study thereby represents a valuable contribution to the literature.

The previous literature demonstrates that multiple mechanisms may link body fat mass and anxiety symptoms. First, systemic inflammation may serve as an important mediator in this relation. Adipose tissue hypertrophy stimulates release of inflammatory

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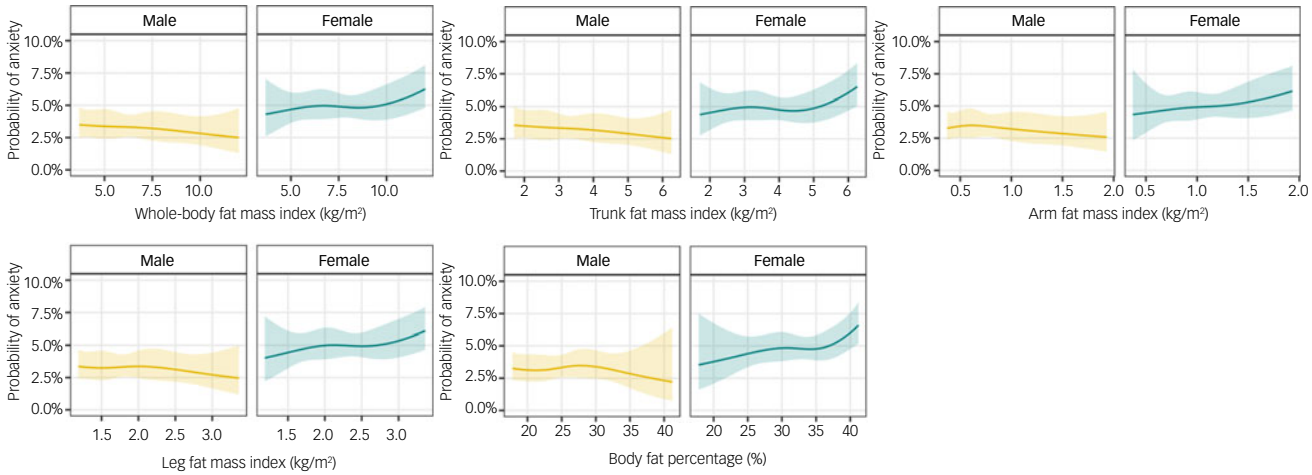


Fig. 2 Nonlinear associations between body fat mass indices and anxiety symptoms in men and women based on restricted cubic spline model.

cytokines such as IL-6 and TNF-α, thereby inducing systemic inflammation.[27] Subsequently, neuroinflammation can lead to alterations in anxiety-related brain circuitry, which may contribute to the pathophysiology of anxiety.[28] Second, alterations in gut microbiota induced by excess body fat can contribute to mental health problems.[29] Although the mechanism is not yet fully understood, changes in the gut microbiome may influence the neuroendocrine system or hypothalamic–pituitary–adrenal axis, contributing to the development of depression or anxiety.[29] Third, in addition to physiological pathways, the psychosocial implications of body fat should be considered. For instance, individuals with excess body fat are more likely to be stigmatised as lazy or lacking self-discipline, making them vulnerable to social isolation and discrimination.[12] Such chronic stress may contribute to the onset of anxiety symptoms.

The observation of significant sex-based differences in the association between body fat mass indices and anxiety symptoms is notable. The exact mechanisms underlying these sex differences are not fully understood. First, studies have indicated that adiposity induces a more pronounced activation of inflammatory pathways in women than in men. For instance, the elevation of high-sensitivity C-reactive protein among individuals with obesity is more pronounced in women than in men.[30,31] Previous studies have also reported a notable sex-specific relationship between body fat distribution and inflammation.[32,33] Although women exhibit greater subcutaneous fat accumulation, whereas men tend to accumulate more visceral fat, subcutaneous adipose tissue volume in women was linked to inflammatory responses, including elevated levels of leptin and increased expression of CD68, TNF-α and IL-1α.[32] Consequently, heightened systemic inflammation among women with excess body fat accumulation may contribute to poor mental health outcomes through neuroinflammatory pathways.[29] Second, there are substantial sex differences in sociocultural factors related to body image and their influence on psychological outcomes. Social media significantly influences individuals' body image, often leading to preoccupation with appearance and body shape dissatisfaction among women.[34] Specifically, in women, the idealisation of thinness may lead to a stronger association between higher body fat and anxiety or depression than in men.[35] Recent sociocultural expectations emphasising a curvier body image for women may also contribute to body dissatisfaction.[36] By contrast, the link between body fat mass and body dissatisfaction may be less pronounced in men.[34,37]

This study had some limitations. First, the causal effects of body fat mass on anxiety could not be established because of the cross-sectional design of the study. The possibility of reverse causation, in which anxiety symptoms lead to increased body fat, should also be considered. The relationship between body fat and mental health problems is bidirectional.[11,38] For example, individuals experiencing anxiety are more likely to engage in maladaptive behaviours, including emotional eating or alcohol consumption, which can contribute to an increase in body fat.[39] Therefore, future longitudinal studies should examine the directionality of this association. Second, several unmeasured factors, including genetic predispositions, history of psychiatric diagnosis and medication use, may influence the relationship between body fat mass and anxiety. However, these factors could not be adjusted for in the present analysis because of a lack of information. Thus, residual confounding may have resulted in overestimation in the relationship between body fat mass indices and anxiety in this study. Third, although the GAD-7 was originally developed as a screening tool, it is a validated measure of anxiety symptoms. Future studies may benefit from incorporating more objective assessments such as physician-confirmed diagnoses.

Despite these limitations, our study had several strengths. First, a complex survey design was used to achieve a representative sample of study participants, which enhanced the generalisability of the findings. Second, body fat mass was directly measured using BIA, in contrast to studies that have relied on proxy indicators of adiposity such as BMI. This methodological approach means the present study contributes meaningfully to the existing literature.

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Supplementary material

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Data availability

The data are publicly accessible at https://knhanes.kdca.go.kr.

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Author contributions

Conceptualisation: S.-U.B. and J.-H.Y.; methodology, formal analysis, data curation, software, investigation, visualisation, writing – original draft: S.-U.B.; writing – review and editing, and supervision: J.-H.Y.

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Declaration of interest

None.

References

1 NCD Risk Factor Collaboration. Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative studies with 222 million children, adolescents, and adults. *Lancet* 2024; **403**: 1027–50.

2 Bae JH, Haam JH, Jeon E, Kang SY, Song S, Park CY, et al. Clinical practice guidelines for the diagnosis and pharmacologic treatment of overweight and obesity by the Korean Society for the Study of Obesity. *J Obes Metab Syndr* 2025; **34**: 322–43.

3 Jeong SM, Jung JH, Yang YS, Kim W, Cho IY, Lee YB, et al. 2023 Obesity fact sheet: prevalence of obesity and abdominal obesity in adults, adolescents, and children in Korea from 2012 to 2021. *J Obes Metab Syndr* 2023; **33**: 27–35.

4 Rubino F, Cummings DE, Eckel RH, Cohen RV, Wilding JPH, Brown WA, et al. Definition and diagnostic criteria of clinical obesity. *Lancet Diabetes Endocrinol* 2025; **13**: 221–62.

5 Amiri S, Behnezhad S. Body mass index and risk of suicide: a systematic review and meta-analysis. *J Affect Disord* 2018; **238**: 615–25.

6 Luppino FS, de Wit LM, Bouvy PF, Stijnen T, Cuijpers P, Penninx BW, et al. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. *Arch Gen Psychiatry* 2010; **67**: 220–9.

7 Amiri S, Behnezhad S. Obesity and anxiety symptoms: a systematic review and meta-analysis. *Neuropsychiatrie* 2019; **33**: 72–89.

8 de Wit L, Have MT, Cuijpers P, de Graaf R. Body mass index and risk for onset of mood and anxiety disorders in the general population: results from the Netherlands Mental Health Survey and Incidence Study-2 (NEMESIS-2). *BMC Psychiatry* 2022; **22**: 522.

9 Friedman M, Chang R, Amin ZM, Rajan T, Singh R, Yousefzai S, et al. Understanding the bidirectional association between obesity and risk of psychological distress and depression in young adults in the US: available evidence, knowledge gaps, and future directions. *Front Psychiatry* 2024; **15**: 1422877.

10 Fulton S, Decarie-Spain L, Fioramonti X, Guiard B, Nakajima S. The menace of obesity to depression and anxiety prevalence. *Trends Endocrinol Metab* 2022; **33**: 18–35.

11 Milaneschi Y, Simmons WK, van Rossum EFC, Penninx BW. Depression and obesity: evidence of shared biological mechanisms. *Mol Psychiatry* 2019; **24**: 18–33.

12 Emmer C, Bosnjak M, Mata J. The association between weight stigma and mental health: a meta-analysis. *Obes Rev* 2020; **21**: e12935.

13 Zhang G, Wang S, Ma P, Li S, Sun X, Zhao Y, et al. Increased regional body fat is associated with depressive symptoms: a cross-sectional analysis of NHANES data obtained during 2011–2018. *BMC Psychiatry* 2024; **24**: 336.

14 Gu W, Bao K, Li X, Xiang S, He J, He J, et al. Association between body fat percentage and depression: a cross-sectional study of NHANES. *J Affect Disord* 2025; **371**: 305–14.

15 Wilcosky T, Wing S. The healthy worker effect. Selection of workers and work forces. *Scand J Work Environ Health* 1987; **13**: 70–2.

16 Ul-Haq Z, Smith DJ, Nicholl BI, Cullen B, Martin D, Gill JM, et al. Gender differences in the association between adiposity and probable major depression: a cross-sectional study of 140,564 UK Biobank participants. *BMC Psychiatry* 2014; **14**: 153.

17 Li Y, Li J, Sun T, He Z, Liu C, Li Z, et al. Sex-specific associations between body composition and depression among U.S. adults: a cross-sectional study. *Lipids Health Dis* 2025; **24**: 15.

18 Baldini I, Casagrande BP, Estadella D. Depression and obesity among females, are sex specificities considered? *Arch Womens Ment Health* 2021; **24**: 851–66.

19 Yi Y, Baek JY, Lee E, Jung H-W, Jang I-Y. A comparative study of high-frequency bioelectrical impedance analysis and dual-energy X-ray absorptiometry for estimating body composition. *Life* 2022; **12**: 994.

20 Spitzer RL, Kroenke K, Williams JB, Lowe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med* 2006; **166**: 1092–7.

21 Ahn JK, Kim Y, Choi KH. The psychometric properties and clinical utility of the Korean version of GAD-7 and GAD-2. *Front Psychiatry* 2019; **10**: 127.

22 Norton EC, Dowd BE, Garrido MM, Maciejewski ML. Requiem for odds ratios. *Health Serv Res* 2024; **59**: e14337.

23 Desquilbet L, Mariotti F. Dose-response analyses using restricted cubic spline functions in public health research. *Stat Med* 2010; **29**: 1037–57.

24 Lumley T. Analysis of complex survey samples. *J Stat Softw* 2004; **9**: 1–19.

25 Lee SH, Shin C, Kim H, Jeon SW, Yoon HK, Ko YH, et al. Validation of the Korean version of the Generalized Anxiety Disorder 7 self-rating scale. *Asia Pac Psychiatry* 2022; **14**: e12421.

26 Kim M, Kim RB, Yang TW, Kim YS, Kim DH, Kwon OY. Optimal cutoff score for diagnosing generalized anxiety disorder with the Generalized Anxiety Disorder 7-item scale in people living with epilepsy: a systematic review with diagnostic test accuracy meta-analysis. *Seizure* 2026; **134**: 229–37.

27 Reilly SM, Saltiel AR. Adapting to obesity with adipose tissue inflammation. *Nat Rev Endocrinol* 2017; **13**: 633–43.

28 Won E, Kim YK. Neuroinflammation-associated alterations of the brain as potential neural biomarkers in anxiety disorders. *Int J Mol Sci* 2020; **21**: 6546.

29 Saravanan D, Khatoon BS, Winner GJ. Unraveling the interplay: exploring the links between gut microbiota, obesity, and psychological outcomes. *Cureus* 2023; **15**: e49271.

30 Choi J, Joseph L, Pilote L. Obesity and C-reactive protein in various populations: a systematic review and meta-analysis. *Obes Rev* 2013; **14**: 232–44.

31 Nari F, Jang BN, Kim GR, Park EC, Jang SI. Synergistic effects and sex differences in anthropometric measures of obesity and elevated high-sensitivity C-reactive protein levels. *Int J Environ Res Public Health* 2020; **17**: 8279.

32 van den Munckhof ICL, Bahrar H, Schraa K, Brand T, Ter Horst R, van der Graaf M, et al. Sex-specific association of visceral and subcutaneous adipose tissue volumes with systemic inflammation and innate immune cells in people living with obesity. *Int J Obes* 2024; **48**: 523–32.

33 Vijayakumar S, Pantha S, Budha Magar S, Dhakal S. Sex differences in the impact of obesity on immunity. *Immunol Rev* 2026; **338**: e70101.

34 Brasil KM, Mims CE, Pritchard ME, McDermott RC. Social media and body image: relationships between social media appearance preoccupation, self-objectification, and body image. *Body Image* 2024; **51**: 101767.

35 He J, Sun S, Zickgraf HF, Lin Z, Fan X. Meta-analysis of gender differences in body appreciation. *Body Image* 2020; **33**: 90–100.

36 Walker DC, Gaither SE, De Los Santos B, Keigan J, Schaefer LM, Thompson JK. Development and validation of a measure of curvy ideals internalization. *Body Image* 2022; **43**: 217–31.

37 He J, Sun S, Lin Z, Fan X. The association between body appreciation and body mass index among males and females: a meta-analysis. *Body Image* 2020; **34**: 10–26.

38 Markowitz S, Friedman MA, Arent SM. Understanding the relation between obesity and depression: causal mechanisms and implications for treatment. *Clin Psychol* 2008; **15**: 1–20.

39 Dakanalis A, Mentzelou M, Papadopoulou SK, Papandreou D, Spanoudaki M, Vasios GK, et al. The association of emotional eating with overweight/obesity, depression, anxiety/stress, and dietary patterns: a review of the current clinical evidence. *Nutrients* 2023; **25**: 1173.

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