*Send Orders for Reprints to reprints@benthamscience.ae*

*Clinical Practice & Epidemiology in Mental Health*, 2016, *12*, 67-74 67

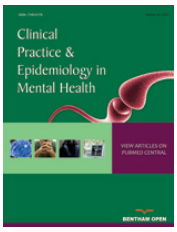
BENTHAM OPEN

CrossMark

# Clinical Practice & Epidemiology in Mental Health

Content list available at: www.benthamopen.com/CPEMH/

DOI: 10.2174/1745017901612010067



RESEARCH ARTICLE

# Associations Between Anxiety Disorder Diagnoses and Body Mass Index Differ by Age, Sex and Race: A Population Based Study

Ramona S. DeJesus[a,*], Carmen R. Breitkopf[b], Jon O. Ebbert[a,c], Lila J. Finney Rutten[b,c], Robert M. Jacobson[d], Debra J. Jacobson[b], Chun Fan[b] and Jennifer St. Sauver[b,c]

[a]*Division of Primary Care Internal Medicine, Department of Medicine, Mayo Clinic, Rochester, MN, USA*
[b]*Department of Health Sciences Research, Mayo Clinic, Rochester, MN, USA*
[c]*Robert D and Patricia E Kern Center for the Science of Health Care Delivery, Mayo Clinic, Rochester, MN, USA*
[d]*Department of Pediatric and Adolescent Medicine, Mayo Clinic Rochester, MN, USA*

Received: April 25, 2016 Revised: September 03, 2016 Accepted: September 16, 2016

**Abstract:**

***Background:***

Few large studies have examined correlations between anxiety and body mass index (BMI) by gender or racial groups using clinical data.

***Objective:***

This study aimed to determine associations between diagnosed anxiety disorders and BMI, and evaluate whether observed associations varied by demographic characteristics.

***Method:***

Data from the Rochester Epidemiology Project (REP) data linkage system were analyzed to examine associations between anxiety disorders and BMI among adults ages 18-85 residing in Olmsted County, MN in 2009 (n=103,557). Height and weight data were available for 75,958 people (73%). The international classification of underweight, overweight, and obesity by BMI was used.

***Results:***

Population consisted of 56% females, 92.8% White individuals, with median age of 46 years. When adjusted for age, sex, and race, we observed a U-shaped association between anxiety and BMI group. Underweight and obese individuals were more likely to have an anxiety diagnosis compared to normal weight individuals. Stratification by sex yielded a U-shaped association between anxiety and BMI only in women. Stratification by race showed a U-shaped association between anxiety and BMI only in the White population. Anxiety was significantly associated only with obesity in the Black population. Anxiety was not associated with a BMI category in Asian or Hispanic groups. Among elderly group, there is inverse correlation between anxiety and obesity.

***Conclusion:***

Our results suggest that anxiety may have heterogeneous associations with BMI in the population. Further research on potential mechanisms contributing to these findings will help direct efforts in anxiety and obesity management across diverse population groups.

**Keywords:** Anxiety, Body mass index, Correlation, Gender, Population based, Race.

* Address correspondence to this author at the Mayo Clinic, 200 First Street SW, Rochester, MN 55905, USA; Tel: (507) 284-0805; Fax: (507) 266-0036; E-mail: dejesus.ramona@mayo.edu

## INTRODUCTION

Anxiety disorders are the most common class of mental health disorders worldwide and in the United States (US) [1, 2]. The estimated lifetime prevalence of any anxiety disorder is over 15% [3]. Obesity is a global epidemic with increasing prevalence in both developed and developing countries [4]. Although its overall prevalence has not increased in the United States, it remains the second leading cause of preventable death and disability in the US. Using the National Health and Nutrition Examination Survey (NHANES) data, it is estimated that more than one third of US adults are obese [4]. Self-reported national survey data from the Behavioral Risk Factor Surveillance System (BRFSS) reveals a significantly higher burden of obesity and risky health behavior among persons with a prior diagnosis of an anxiety disorder [5]. Obesity is a strong predictor of chronic medical conditions and obesity-related chronic conditions could increase the risk of anxiety [6 - 8]. Plausible biopsychosocial mechanisms linking anxiety and obesity have also been proposed [9, 10].

The association between depression and obesity is well supported by systematic reviews and meta-analyses [11, 12]. Published reports have also shown significant associations between anxiety and obesity [13, 14]; however, in these studies, calculation of body mass index (BMI) has been done from survey reports and the BMI based on self-reported information underestimates its prevalence [15]. In addition, overweight/obese adults have been observed to have size misperception and frequently underestimate their sizes [16]. The correlation between anxiety disorders and BMI derived from clinical data has not been widely explored.

Similarly, several studies have reported on the associations between depression and BMI by race and gender [17, 18]. Only a handful of studies have looked into the correlation between anxiety and BMI separately in men and women, different age groups, or among ethnic populations. Results from the BRFSS demonstrated differences in the prevalence of both anxiety and depression among people with different BMI levels, but lifetime diagnoses of these conditions were self-reported and while observed associations differed by sex, other demographic correlations were not closely explored [19]. Therefore, it is not clear whether associations between anxiety and BMI vary in different populations.

The bidirectional relationship between obesity and major depression has been clearly demonstrated; obesity at baseline increased the risk of depression onset and *vice versa* [12]. For obesity management to be effective, co-morbid depression also needs to be addressed. It is crucial that we likewise examine the relationship between BMI and anxiety as well as identify relevant correlations that potentially can impact treatment response.

We used clinical data to derive population-based estimates of diagnosed anxiety disorders and BMI status to examine associations between diagnosed anxiety disorders and BMI, and to determine whether associations between diagnosed anxiety and BMI varied in persons with different demographic characteristics.

## MATERIALS AND METHODOLOGY

Data from the Rochester Epidemiology Project (REP) data linkage system were analyzed to examine associations between anxiety disorders and BMI among adults ages 18-85 residing in Olmsted County, MN in 2009 (n=103,557). The REP links data on medical care delivered at multiple health care institutions to virtually the entire population of Olmsted County, MN; details of the project had previously been reported [17]. Computerized diagnostic indices of the REP were searched electronically to extract all International Classification of Diseases, ninth revision (ICD-9) codes for Charlson Index diagnoses, depression diagnoses and the following anxiety disorder codes: generalized anxiety disorder, phobias (social phobia, agoraphobia with and without panic isolated phobias NEC and phobia NOS), panic disorder, obsessive compulsive disorder, post-traumatic stress disorder (PTSD), and anxiety unspecified (anxiety state NOS, organic anxiety syndrome) derived from any visit type. Electronic height and weight data were available for 75, 958 people (73%). The study was reviewed and approved by the Institutional Review Board.

### Statistical Analysis

The BMI was calculated as $kg/m^2$. Since the data were skewed, medians for BMI measurements were calculated and categorized into underweight (BMI<18.5), normal weight (18.5≤BMI<25), overweight (25≤BMI30), and obese (BMI≥30) using the international classification of adult weight. Logistic regression models were used to estimate the associations between any anxiety disorder and BMI categories with normal weight as the reference group. Multivariable models were used to adjust for confounding effects of age, sex, race and Charlson Index. Stratified models were used to assess potential interactions. Additional models were used to estimate the association between PTSD and BMI. Results are presented as odds ratios (ORs) and 95% confidence intervals (CIs). All analyses were performed using SAS,

Version 9.3 (SAS Institute, Cary, NC).

## RESULTS

The population consisted of 56% females (n=42,976), predominantly white individuals (92.8%), with a median (Q1, Q3) Charlson score of 0 (0, 1) and the largest age group was between 29-49 years of age (Table **1**). Median BMI was lower among Asians compared to other ethnic groups. Overall, only 5.2% (n=3,985) had an ICD-9 coded anxiety disorder diagnosis. Generalized anxiety disorder (GAD) was a diagnosis in 1% of the individuals. No significant associations were observed between median BMI and specific diagnoses of GAD, phobias, panic disorder, and obsessive compulsive disorder. However, a diagnosis of post-traumatic stress disorder (PTSD) and other anxiety (anxiety state/anxiety disorder) were significantly associated with BMI (*P* value .001 and .02 respectively). There was a diagnosis of depression for 26% and 8% of individuals with and without an anxiety disorder diagnosis.

**Table 1. Population characteristics (Olmsted County 2009).**

| Characteristics | N (%) | BMI Median (Q1, Q3) | *P* value[a] |
|---|---|---|---|
| Sex | | | |
| Male | 32,982 (43.4) | 28.0 (25.0, 31.7) | <.001 |
| Female | 42,976 (56.6) | 26.3 (22.7, 31.4) | |
| Age group | | | |
| ≥18-29 | 17,247 (22.7) | 24.5 (21.8, 28.7) | <.001 |
| >29-49 | 26,734 (35.2) | 27.3 (23.8, 31.8) | |
| >49-64 | 19,076 (25.1) | 28.6 (25.1, 33.0) | |
| >64-85 | 12,901 (17.0) | 28.1 (25.0, 31.8) | |
| Race/ethnicity | | | |
| White | 70,461 (92.8) | 27.3 (23.8, 31.7) | <.001 |
| Black | 2,073 (2.7) | 27.6 (23.7, 32.4) | |
| Asian | 2,388 (3.1) | 24.1 (21.7, 27.0) | |
| Hispanic | 861 (1.1) | 27.9 (24.5, 32.6) | |
| Other | 175 (0.2) | 28.5 (24.2, 32.5) | |
| Anxiety | | | |
| No anxiety code | 71,973 (94.8) | 27.2 (23.7, 31.6) | |
| Generalized anxiety disorder | 758 (1.0) | 27.2 (23.6, 31.4) | .65 |
| Phobias | 379 (0.5) | 27.4 (23.3, 33.3) | .43 |
| Panic disorder | 307 (0.4) | 27.1 (23.6, 31.5) | 1.00 |
| Obsessive compulsive disorder | 173 (0.2) | 26.5 (23.3, 30.7) | .21 |
| Post-traumatic stress disorder | 329 (0.4) | 28.7 (24.0, 33.7) | .001 |
| Other anxiety (anxiety state/anxiety disorder) | 2,249 (3.0) | 26.8 (23.3, 31.5) | .02 |
| Any anxiety | 3,985 (5.3) | 27.1 (23.4, 31.8) | .34 |

Abbreviations: BMI, Body Mass Index

[a]Kruskal Wallace *P*-value comparing BMI across groups by demographics and anxiety diagnosis *P*-value

**Table 2. Relationship between any anxiety and BMI (Olmsted County 2009).**

| | Underweight BMI<18.5 | Normal weight 18.5≤BMI<25 | Overweight 25≤BMI≥29 | Obese BMI≥30 |
|---|---|---|---|---|
| | OR (95% CI) | | OR (95% CI) | OR (95% CI) |
| Unadjusted | 1.41 (1.14, 1.75) | Referent | 0.85 (0.79, 0.92) | 0.97 (0.90, 1.05) |
| Adjusted for age, sex, race, Charlson index | 1.31 (1.06, 1.63) | Referent | 0.99 (0.91, 1.07) | 1.09 (1.00, 1.18) |

Abbreviations: BMI, Body Mass Index; CI, Confidence Interval; OR, Odds Ratio

After adjustment for age, sex, race, and Charlson score only individuals who were underweight and obese (OR 1.31; 95% CI 1.06, 1.63 and OR 1.09; CI 1.00, 1.18, respectively, adjusted model likelihood ratio $\chi^2$=472, p<0.0001) were more likely to have an anxiety diagnosis compared to those of normal weight (Table **2**). When assessing the relationship between an anxiety diagnosis of PTSD and BMI, we saw a slightly lower and non-significant association (adjusted OR (95% CI) of 1.2 (0.6, 2.7)) for those who were underweight, and a stronger association (adjusted OR (95% CI) of 1.4

(1.1, 1.9) and 2.0 (1.5, 2.6)), seen for those who were overweight and obese, respectively (data not shown).

A significant association between anxiety and BMI was observed only in women when the data were stratified by sex (Table **3**). Among this group, there was a positive association between anxiety and being underweight or obese. Stratification by race with an adjustment for age and sex showed a significant association between anxiety and BMI among the White and Black population groups, but not in the Asian or Hispanic groups. A U-shaped association with anxiety was observed in the White population, but not the Black population. Instead, in the Black population group, anxiety was associated with only obesity. Age stratification also yielded a U-shaped association with anxiety but only among the younger age groups (18-29 years). In older adults particularly those over 64 years, obesity had an inverse association with anxiety. The overall chi-square for all models stratified by sex and age group were significant ($p<0.0001$). When stratified by race, the overall chi-square for the models for blacks ($p=0.039$) and whites ($p<0.0001$) were both significant.

**Table 3. Relationship between anxiety and BMI stratified by sex, race, and age.**

| | **Underweight BMI<18.5** | **Normal weight 18.5≤BMI<25** | **Overweight 25≤BMI≥29** | **Obese BMI≥30** |
|---|---|---|---|---|
| Sex[a] | OR (95%CI) | | OR (95% CI) | OR (95% CI) |
| Men | 1.39 (0.88, 2.20) | Referent | 0.93 (0.81, 1.07) | 0.98 (0.85, 1.13) |
| Women | 1.30 (1.02, 1.66) | Referent | 1.01 (0.92, 1.12) | 1.14 (1.03, 1.25) |
| Race[b] | | | | |
| White | 1.33 (1.07, 1.67) | Referent | 0.99 (0.91, 1.07) | 1.07 (0.99, 1.17) |
| Black | 1.03 (0.23, 4.58) | Referent | 1.66 (0.87, 3.15) | 2.35 (1.29, 4.29) |
| Asian | 1.17 (0.35, 3.90) | Referent | 0.93 (0.50, 1.73) | 0.94 (0.39, 2.29) |
| Hispanic | 0.92 (0.11, 7.45) | Referent | 0.83 (0.40, 1.73) | 0.88 (0.44, 1.76) |
| Other | 6.73(0.46, 99.21) | Referent | 1.28 (0.19, 8.48) | 2.02 (0.38, 10.70) |
| Age group[c] | | | | |
| 18-29 | 1.36 (0.99, 1.86) | Referent | 1.16 (1.00, 1.36) | 1.32 (1.12, 1.55) |
| 29-49 | 0.91 (0.55, 1.50) | Referent | 1.01 (0.89, 1.16) | 1.24 (1.09, 1.40) |
| 49-64 | 1.55 (0.86, 2.80) | Referent | 0.92 (0.76, 1.10) | 0.79 (0.66, 0.94) |
| 64-85 | 1.95 (1.19, 3.20) | Referent | 0.54 (0.43, 0.67) | 0.62 (0.49,0.77) |

Abbreviations: BMI, Body Mass Index; CI, Confidence Interval; OR, Odds Ratio

[a]Results adjusted for age, race and Charlson index.

[b]Results adjusted for age, sex, and Charlson index.

[c]Results adjusted for sex, race, and Charlson index.

## DISCUSSION

In this study, we observed an overall U-shaped association between anxiety and BMI in a large, Midwestern population. The overall results are consistent with previous findings from the BRFSS, which showed an increased prevalence of anxiety among participants who were underweight and obese [19]. A similar pattern was observed in a nationally representative household survey conducted in New Zealand involving over 12,000 participants [13]. This U-shaped association has also been reported in studies examining relationships between depression and BMI [19, 18]. Previous research has identified possible mechanisms to explain the relationship between anxiety and obesity [9, 10]. For example, dysregulation by obesity of several shared biological pathways such as immuno-inflammatory processes, oxidative stress, neurotransmitter balance, and neuroprogression have all been associated with anxiety. Other reported mediators of the relationship between psychiatric disorders and obesity are behavioral and include current and past unhealthy dietary patterns, lower rates of physical activity, and increased sedentary behaviors documented among obese individuals [20, 21]. The role of psychotropic medications used in mood disorders on increased BMI is well reported [22, 23]. It has also been observed that individuals from various ethnic backgrounds differ in how they view themselves whether as obese or as normal weight [24]. In those who are underweight, the drive for thinness, distorted body image, low self-esteem, and media influence linking thinness and muscularity to ideal physique have been correlated with anxiety and body dissatisfaction [25, 26]. Our findings add to the growing evidence that BMI and anxiety have a non-linear association and that anxiety may be important at both ends of the weight spectrum

We observed no significant association between BMI and various subtypes of anxiety diagnoses with the exception of PTSD and other anxiety (anxiety state/anxiety disorder). Results of a meta-analysis by Gariepy *et al.* supported this

finding [14]. Our study showed a stronger association between PTSD and those who were overweight or obese; this association appears to be linear instead of U shaped. While a possible link between PTSD and obesity risk has been reported, we know of only one other study that showed PTSD, along with social phobia, to be strongly associated with obesity compared with other anxiety subtypes [13]. Reports that linked childhood abuse with adult obesity and PTSD with binge-eating disorder suggest a possible pathway from past trauma to obesity that is mediated by emotionally-driven binge-eating [27, 22].

Our results indicate that associations between anxiety and BMI vary substantially within different demographic groups. In a sub-analysis based on race, we found a significant association between anxiety and BMI among underweight and obese White individuals following a U-shaped pattern. In contrast, this association was only seen among obese but not among underweight Blacks following more of a J-shaped curve. There was no significant association between anxiety and BMI among Asians or Hispanics. Previous studies examining associations between anxiety and BMI in racial or ethnic minority populations are limited, particularly in the US. Lifetime diagnosis of anxiety was also low among Hispanics in the BRFSS study compared to non-Hispanic whites but this observation was not associated with BMI [19]. Interestingly, contrasting findings have been reported in studies of other population cohorts. For instance, a study including 1,584 young Nigerian adults found no significant correlation between various subsets of anxiety and BMI [23], whereas a symmetrical U-shaped relationship between psychological distress and BMI status was noted in a Mediterranean Spanish population [28]. After controlling for age, Kelly *et al.* only found significantly greater odds of mental illness in the obese and not in the underweight among 46,704 Australian subjects [29]. Hence, while it appears that race may have a modulating effect on the interaction between anxiety and BMI, other variables may play equally important roles including socioeconomic conditions, lifestyle, geographical location, and cultural differences. Exploring these characteristics further may help identify underlying mechanisms that would account for the observed inconsistencies in findings.

Similarly heterogeneous outcomes were seen when looking into the correlation between anxiety and BMI stratified by age or sex. We found a U-shaped association between anxiety and BMI among women in our study, but not in men. Instead, there was a non-significant association between anxiety and underweight among men. Interestingly, more than half of published studies that stratified data by gender supported a significantly positive trend for anxiety among obese women; however the same was not seen in men [15]. The systematic review conducted by Gariepy *et al.* even confirmed a positive association between anxiety and obesity in both male and female sexes [14]. These results differ from previously reported BRFSS data, which did not show sex to be a significant moderating factor [30]. Two other studies also did not see sex as a conditioning variable to the relationship between anxiety and obesity [13]. This disparity between our observation and those of others may be attributed to yet unidentified variables that seem to modulate sex effect on anxiety and BMI; it further affirms the complexity in the association between these two entities.

The lifetime prevalence of anxiety in the BRFSS study was lowest among those ≥70 years of age [19], a finding confirmed in this study. Not only did we observe a declining prevalence of anxiety with advancing age, we also noted contrasting correlations between anxiety and BMI in individuals from 49 to 85 years of age. Specifically, being underweight and elderly was associated with increased anxiety, while being obese and elderly had the opposite association. Other studies had reported on this age-related phenomenon. A large study conducted by Brandheim *et al.* among Swedish adults also showed that psychological distress decreases with increasing age, regardless of BMI [31]; while another study reported a diminishing probability of having common mental disorders (depression and anxiety) with rising BMI in older age groups [32]. Kelly and associates likewise noted that elevated odds of mental illness were apparent for middle-age persons, while lower odds were seen in older individuals [26]. What accounts for increased odds of having anxiety in underweight older adults has not been well explored but presence of frailty and potential confounders such as declining physical health and physical inactivity have been suggested [17, 33]. Thus, it appears that among the older population groups, being underweight is associated with anxiety whereas, weight gain may have a mitigating effect on the likelihood of having anxiety. Further elucidation of factors underlying this observation would potentially introduce new areas of focus in mental health care among the elderly.

The main strength of this study resides in its large sample size which allowed for analysis of sub-populations, particularly racial and ethnic minority populations. Likewise, data were obtained using the Rochester Epidemiology Project linkage system to electronic health records; thus, controlling for biases associated with self-reported mental health diagnoses and weight. A limitation of this study is that ICD code diagnoses where derived from any visit time with no knowledge of who made the diagnosis (primary care physician or mental health specialist). Some disorders may therefore been under- or over-diagnosed. We likewise did not have data available on possible confounding factors (such

as socioeconomic status and psychotropic medication usage) that might account for the observed associations. The percentage of those with and without an anxiety diagnosis that also had co-morbid depression was 26% and 8% respectively. We did not adjust for depression as the two entities are highly correlated and it was not possible to separate out the individual effects of depression in our study; hence, its potential impact on study results was not determined. The demographic characteristics examined in this study are likely just a marker for the underlying mechanisms that explain the observed associations. However, these results do suggest interesting differences by race/ethnicity/age and point to groups that warrant further more detailed study. Our study was also limited by its cross-sectional nature; longitudinal studies might offer better insight on observed associations. Moreover, the Olmsted County population captured by the REP accurately reflects the upper Midwest population in gender, age group, and sex [34]; however, findings may differ in other locations. In particular, if race/ethnicity is simply a marker for an underlying characteristic such as socioeconomic status, these results may not be generalizable to other populations. Replication of this study in other populations would be useful for understanding underlying characteristics that may drive the observed associations between anxiety disorders and BMI.

## CONCLUSION

Using clinical data, our study showed a non-linear U-shaped association between anxiety and BMI classifications. Of greater implication to population health management, our results suggest that anxiety may have heterogeneous associations with BMI that are potentially influenced by demographic characteristics. Further research on possible mechanisms that would account for this finding may help direct efforts in both anxiety and obesity management in diverse populations.

## CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

## ACKNOWLEDGEMENTS

This project and publication was supported by the Population Health Science Scholars Program from the Robert D and Patricia E Kern Center for the Science of Health Care Delivery. Its contents are solely the responsibility of the authors and do not necessarily represent the official view of the Robert D and Patricia E Kern Center for the Science of Health Care Delivery.

## REFERENCES

[1] Demyttenaere K, Bruffaerts R, Posada-Villa J, *et al.* Prevalence, severity, and unmet need for treatment of mental disorders in the World Health Organization World Mental Health Surveys. JAMA 2004; 291(21): 2581-90.
[http://dx.doi.org/10.1001/jama.291.21.2581] [PMID: 15173149]

[2] Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, Walters EE. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. Arch Gen Psychiatry 2005; 62(6): 593-602.
[http://dx.doi.org/10.1001/archpsyc.62.6.593] [PMID: 15939837]

[3] Kessler RC, Aguilar-Gaxiola S, Alonso J, *et al.* The global burden of mental disorders: an update from the WHO World Mental Health (WMH) surveys. Epidemiol Psichiatr Soc 2009; 18(1): 23-33.
[http://dx.doi.org/10.1017/S1121189X00001421] [PMID: 19378696]

[4] Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA 2014; 311(8): 806-14.
[http://dx.doi.org/10.1001/jama.2014.732] [PMID: 24570244]

[5] Strine TW, Mokdad AH, Balluz LS, *et al.* Depression and anxiety in the United States: findings from the 2006 behavioral risk factor surveillance system. Psychiatr Serv 2008; 59(12): 1383-90.
[http://dx.doi.org/10.1176/ps.2008.59.12.1383] [PMID: 19033164]

[6] OSullivan JB. Body weight and subsequent diabetes mellitus. JAMA 1982; 248(8): 949-52.
[http://dx.doi.org/10.1001/jama.1982.03330080031024] [PMID: 7097963]

[7] Beuther DA, Sutherland ER. Overweight, obesity, and incident asthma: a meta-analysis of prospective epidemiologic studies. Am J Respir Crit Care Med 2007; 175(7): 661-6.
[http://dx.doi.org/10.1164/rccm.200611-1717OC] [PMID: 17234901]

[8] Kroenke K, Spitzer RL, Williams JB, Monahan PO, Löwe B. Anxiety disorders in primary care: prevalence, impairment, comorbidity, and detection. Ann Intern Med 2007; 146(5): 317-25.
[http://dx.doi.org/10.7326/0003-4819-146-5-200703060-00004] [PMID: 17339617]

[9] Sinha R, Jastreboff AM. Stress as a common risk factor for obesity and addiction. Biol Psychiatry 2013; 73(9): 827-35. [http://dx.doi.org/10.1016/j.biopsych.2013.01.032] [PMID: 23541000]

[10] Lopresti AL, Drummond PD. Obesity and psychiatric disorders: commonalities in dysregulated biological pathways and their implications for treatment. Prog Neuropsychopharmacol Biol Psychiatry 2013; 45: 92-9. [http://dx.doi.org/10.1016/j.pnpbp.2013.05.005] [PMID: 23685202]

[11] de Wit L, Luppino F, van Straten A, Penninx B, Zitman F, Cuijpers P. Depression and obesity: a meta-analysis of community-based studies. Psychiatry Res 2010; 178(2): 230-5. [http://dx.doi.org/10.1016/j.psychres.2009.04.015] [PMID: 20462641]

[12] Luppino FS, de Wit LM, Bouvy PF, *et al.* Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry 2010; 67(3): 220-9. [http://dx.doi.org/10.1001/archgenpsychiatry.2010.2] [PMID: 20194822]

[13] Scott KM, McGee MA, Wells JE, Oakley Browne MA. Obesity and mental disorders in the adult general population. J Psychosom Res 2008; 64(1): 97-105. [http://dx.doi.org/10.1016/j.jpsychores.2007.09.006] [PMID: 18158005]

[14] Gariepy G, Nitka D, Schmitz N. The association between obesity and anxiety disorders in the population: a systematic review and meta-analysis. Int J Obes 2010; 34(3): 407-19. [http://dx.doi.org/10.1038/ijo.2009.252] [PMID: 19997072]

[15] Connor Gorber S, Tremblay M, Moher D, Gorber B. A comparison of direct *vs.* self-report measures for assessing height, weight and body mass index: a systematic review. Obes Rev 2007; 8(4): 307-26. [http://dx.doi.org/10.1111/j.1467-789X.2007.00347.x] [PMID: 17578381]

[16] Paul TK, Sciacca RR, Bier M, Rodriguez J, Song S, Giardina EG. Size misperception among overweight and obese families. J Gen Intern Med 2015; 30(1): 43-50. [http://dx.doi.org/10.1007/s11606-014-3002-y] [PMID: 25223750]

[17] St Sauver JL, Grossardt BR, Yawn BP, *et al.* Data resource profile: the Rochester Epidemiology Project (REP) medical records-linkage system. Int J Epidemiol 2012; 41(6): 1614-24. [http://dx.doi.org/10.1093/ije/dys195] [PMID: 23159830]

[18] de Wit LM, van Straten A, van Herten M, Penninx BW, Cuijpers P. Depression and body mass index, a u-shaped association. BMC Public Health 2009; 9: 14. [http://dx.doi.org/10.1186/1471-2458-9-14] [PMID: 19144098]

[19] Zhao G, Ford ES, Dhingra S, Li C, Strine TW, Mokdad AH. Depression and anxiety among US adults: associations with body mass index. Int J Obes 2009; 33(2): 257-66. [http://dx.doi.org/10.1038/ijo.2008.268] [PMID: 19125163]

[20] Hsiao PY, Jensen GL, Hartman TJ, Mitchell DC, Nickols-Richardson SM, Coffman DL. Food intake patterns and body mass index in older adults: a review of the epidemiological evidence. J Nutr Gerontol Geriatr 2011; 30(3): 204-24. [http://dx.doi.org/10.1080/21551197.2011.591266] [PMID: 21846239]

[21] Azevedo Da Silva M, Singh-Manoux A, Brunner EJ, *et al.* Bidirectional association between physical activity and symptoms of anxiety and depression: the Whitehall II study. Eur J Epidemiol 2012; 27(7): 537-46. [http://dx.doi.org/10.1007/s10654-012-9692-8] [PMID: 22623145]

[22] Gustafson TB, Sarwer DB. Childhood sexual abuse and obesity. Obes Rev 2004; 5(3): 129-35. [http://dx.doi.org/10.1111/j.1467-789X.2004.00145.x] [PMID: 15245381]

[23] Ejike CE. Association between anxiety and obesity: A study of a young-adult Nigerian population. J Neurosci Rural Pract 2013; 4(Suppl. 1): S13-8. [http://dx.doi.org/10.4103/0976-3147.116429] [PMID: 24174782]

[24] Breitkopf C, Littleton H, Berenson A. Body image: A study in a tri-ethnic sample of low income women. Sex Roles 2007; 56(5-6): 373-80. [http://dx.doi.org/10.1007/s11199-006-9177-x]

[25] Owen R, Spencer RM. Body ideals in women after viewing images of typical and healthy weight models. Body Image 2013; 10(4): 489-94. [http://dx.doi.org/10.1016/j.bodyim.2013.04.005] [PMID: 23722050]

[26] Groesz LM, Levine MP, Murnen SK. The effect of experimental presentation of thin media images on body satisfaction: a meta-analytic review. Int J Eat Disord 2002; 31(1): 1-16. [http://dx.doi.org/10.1002/eat.10005] [PMID: 11835293]

[27] Hudson JI, Hiripi E, Pope HG Jr, Kessler RC. The prevalence and correlates of eating disorders in the National Comorbidity Survey Replication. Biol Psychiatry 2007; 61(3): 348-58. [http://dx.doi.org/10.1016/j.biopsych.2006.03.040] [PMID: 16815322]

[28] Martínez EV, Gutiérrez-Bedmar M, García-Rodríguez A, Mariscal A, Muñoz-Bravo C, Navajas JF. Weight status and psychological distress in a Mediterranean Spanish population: a symmetric U-shaped relationship. Nutrients 2014; 6(4): 1662-77. [http://dx.doi.org/10.3390/nu6041662] [PMID: 24763112]

[29] Kelly SJ, Daniel M, Dal Grande E, Taylor A. Mental ill-health across the continuum of body mass index. BMC Public Health 2011; 11: 765. [http://dx.doi.org/10.1186/1471-2458-11-765] [PMID: 21975214]

[30] Mukherjee S. Comparing adult males and females in the United States to examine the association between body mass index and frequent mental distress: An analysis of data from BRFSS 2011. Psychiatry J 2013. 2013: 230928

[31] Brandheim S, Rantakeisu U, Starrin B. BMI and psychological distress in 68,000 Swedish adults: a weak association when controlling for an age-gender combination. BMC Public Health 2013; 13: 68. [http://dx.doi.org/10.1186/1471-2458-13-68] [PMID: 23347701]

[32] McCrea RL, Berger YG, King MB. Body mass index and common mental disorders: exploring the shape of the association and its moderation by age, gender and education. Int J Obes 2012; 36(3): 414-21. [http://dx.doi.org/10.1038/ijo.2011.65] [PMID: 21427699]

[33] Molarius A, Berglund K, Eriksson C, *et al.* Mental health symptoms in relation to socio-economic conditions and lifestyle factorsa population-based study in Sweden. BMC Public Health 2009; 9: 302. [http://dx.doi.org/10.1186/1471-2458-9-302] [PMID: 19695085]

[34] St Sauver JL, Grossardt BR, Leibson CL, Yawn BP, Melton LJ III, Rocca WA. Generalizability of epidemiological findings and public health decisions: an illustration from the Rochester Epidemiology Project. Mayo Clin Proc 2012; 87(2): 151-60. [http://dx.doi.org/10.1016/j.mayocp.2011.11.009] [PMID: 22305027]