The Combined Role of Obesity and Depressive Symptom in the Association with Ischemic Heart Disease and Its Subtypes

Shuo liu
Department of Epidemiology and Health Statistics, Qingdao University Medical college
Jia Luo
Department of Epidemiology and Health Statistics, Qingdao University Medical college
Tianhao Zhang
Department of Epidemiology and Health Statistics, Qingdao University Medical college
Dongfeng Zhang
Department of Epidemiology and Health Statistics, Qingdao University Medical college
Hua Zhang (qdcdcsq@163.com)
Municipal Centre of Disease Control and Prevention of Qingdao

Research Article

Keywords: depressive symptoms, ischemic heart disease, obesity, additive interaction

Posted Date: January 18th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1253518/v1

Abstract

This cross-sectional study aimed to explore the combined effects of depression and obesity on ischemic heart disease and its subtypes. Data from the National Health and Nutrition Examination Survey 2007–2018 were used. A total of 29,050 participants aged 20 years or older were included in the analyses. Logistic regression models and restricted cubic spline models were applied to evaluate the associations between depression symptom and ischemic heart disease. There were significant correlations between depressive symptoms and ischemic heart disease [OR and 95%CI: 2.44(1.91,3.10)] and its subtypes: coronary heart disease [2.32(1.67,3.23)], heart attack [2.18(1.71,2.78)], and angina [2.72(1.96,3.79)].The synergistic effects of depression with obesity (BMI≥30) and central obesity (waist ≥102/88cm for men/women) on ischemic heart disease were estimated and expressed using the relative excess risk due to interaction (RERI) and the attributable proportion due to interaction (AP). The RERI and AP with 95% CIs of depression and central obesity for ischemic heart disease were 1.10(0.01,2.19) and 0.35(0.06,0.64). When we analysed the other three subtypes of ischemic heart disease, we only found depressive symptoms and central obesity could have a meaningful synergistic effect on heart attack (RERI: 0.84(-0.28, 1.96) AP:(0.31(0.00, 0.69)).

1. Introduction

According to WHO's Global Health Estimates, ischemic heart disease is the leading cause of death globally, and it was responsible for 16% of the world's total deaths[1]. On the basis of some epidemiological studies, the occurrence of ischemic heart disease is related to many factors, such as smoking[2], high consumption of fatty[3], and a lack of exercise[4]. In some recent studies, several social and psychological factors may also contribute to ischemic heart disease[5-13].

Depression is a common mental illness. Worldwide, In recent years, more than 300 million people suffer from depression each year[14]. Some pathological studies have found that depression can activate inflammatory pathways by increasing pro-inflammatory factors[15]. Moreover, depression is also associated with changes in platelet function and impaired endothelial function[16, 17]. All of these factors may contribute to the onset of ischemic heart disease. Some epidemiological studies have revealed the relationship between depression and ischemic heart disease [5, 18, 19]. A meta-analysis, which combined longitudinal evidence from 21 studies involving more than 120,000 subjects, concluded that depression increased the risk of cardiovascular disease by 80-90 %[20]. However, most studies adjusted for conventional risk factors incompletely, and the adjusted risk estimates might be exaggerated.

Over the past two decades, obesity has become a public health problem worldwide, affecting children and adults alike. Many studies have confirmed that obesity is an independent risk factor for cardiovascular disease. Adipokines released by adipose tissue can induce endothelial dysfunction, systemic inflammation, and insulin resistance, all of those can increase the risk of atherosclerosis [21-23].

From what has been discussed above, depressive symptoms and obesity share pathophysiological pathways that include exacerbating inflammatory responses and endothelial dysfunction, which may contribute to the formation of atherosclerosis[23, 24]. Therefore, a possible mechanism is proposed that depression and obesity may mutually promote their respective pathophysiological mechanisms to contribute to the development of ischemic heart disease [25-27]. According to speculation, it is suggested that there may be a synergistic effect between depressive symptoms and obesity. To date, limited studies have explored that the synergy effect between depressive symptoms and obesity, and the results have been inconsistent. Few studies have explored this combined effect on different types of ischemic heart disease A study of American adults by Brittanny et al. found significant interactions between obesity and depression[28]. However, in the study by Elisabeth et al., the interaction between depressive symptoms and obesity was reversed and not statistically significant[29]. These inconsistent findings highlight the need for continued research into the combined role of depression and obesity in ischemic heart disease. Therefore, in this study, we will explore the synergistic effects of depressive symptom and obesity on ischemic heart disease.

2. Materials And Methods

2.1. Study population

NHANES is a population-based study in the United States. researchers use a complex, layered, multi-stage, probabilistic sampling method to select a representative population. Since 1999, data have been collected on a biennial cycle. It includes a personal interview and a standardized medical examination[30]. The protocol is approved by the Ethics Review Committee of the National Center for Health Statistics and receive the written informed consent of the participants[31]. The methods used in this article were in accordance with relevant guidelines and regulations.

A total of 59842 participants in the NHANES survey during 2007–2018 were included in our study. We selected participants 20 years of age or older for the study, a total of 34770 people. From these participants, we excluded participants with incomplete information from either the depression questionnaire (n = 4926) or the ischemic heart disease questionnaire (n = 200). Females who were pregnant (n = 274) or breast-feeding (n = 212) were also excluded. In addition, we excluded individuals with extreme energy intake (500 or 5000 kcal/day for women and 500 or 8000 kcal/day for men) (n = 108). The end, the study had 29,050 participants (14509 males and 14541 females) (Figure 1).

2.2. Depressive symptom assessment

In NHANES, depressive symptom status is assessed using the Patient Health Questionnaire (PHQ-9). The questionnaire assess the frequency of nine depressive symptoms in the past two weeks[32]. The total scores for PHQ-9 range from 0 to 27, where each question is on a 4-point Likert scale, 0 = "none at all," 1 = "a few days," 2 = "more than half the time," and 3 = "almost every day." We used a score ≥10 as the standard for depressive symptoms. The sensitivity and specificity of the questionnaire for major depression [33] are 88% and 88%, respectively.

2.3 Obesity assessment

Waist circumferences(WC) were measured during minimal respiration to the nearest 0.1 cm at the level of the iliac crest[33].. BMI was calculated as weight in kilograms divided by the square of height in meters. Central obesity was defined as a WC of ≥ 102 cm for males and ≥ 88 cm for females according to the American Heart Association's (AHA) definition[34]. We also used BMI ≥ 30 kg/m^2 based on the WHO definition of obesity[35].

2.4 ischemic heart diseases outcomes

We took ischemic heart disease as the primary outcome. Ischemic heart disease was defined if one of our pre-specified secondary outcomes (coronary heart disease, angina and heart attack) occurred[36]. Secondary outcomes were assessed during personal interviews using a standardized health status questionnaire in which participants were asked "Has a doctor or other health professional ever told you that you have coronary artery disease angina/heart attack?". The average interval between individual interviews and mobile test center (MTC) tests was 2 weeks.

2.5 Covariates

By assessing the association between depression symptoms and ischemic heart disease, covariates were selected and controlled. We selected covariates for age, sex, race, education, income, work activity, recreational activity, smoking, alcohol use, diabetes, hypertension, and BMI. The selection of covariates was based on similar studies [28, 29]. These covariates were used when we used logistic regression to explore the relationship between depressive symptoms and ischemic heart disease. When we calculated RERIs and APs, we omitted BMI from the covariables. See Table S1 for a detailed description of related covariates.

2.6 Statistical analyses

We used STATA 15.0, SPSS26.0, and R programming language 4.0.3 for our analyses. NHANES guidelines recommend that multiple cycles be combined for estimation in order to increase the sample size. To explain the complexity of the sampling design, appropriate sampling weights, original sampling units, and stratigraphic information were selected for analysis. When combining two or more consecutive periods, a new sample weight must be constructed before any analysis can be initiated.

We used mean ± standard deviation to represent normally distributed variables, median (quartile range) to represent non-normally distributed variables, and categorical variables were represented by numbers (percentage). According to the Kolmogorov-Smirnov normality test, scores on the depression scale had a non-normal distribution and were described using the median (quartile range). For continuous variables, if the variables were normally distributed, we used the students' T-test to compare the average level of continuous variables between participants with and without depressive symptoms. Otherwise, nonparametric tests were used. In addition, the Chi-square test were used to compare the percentage of categorical variables between groups. Univariate and multivariate logistic regression analyses were used

to assess the association between depressive symptoms and risk of ischemic heart disease and its subtypes, including coronary heart disease, myocardial infarction, and angina pectoris. Depressive symptoms and depression scores were analyzed the model as categorical variables and continuous variables, respectively. Model 1 Adjusted for age and sex; Model 2 adjusted for all covariates. Odds ratio (OR) and 95% confidence interval (CI) were calculated. The dose-response relationship was evaluated by the restricted cubic spline, with three segments located in the 5th, 50th, and 95th percentiles of the scale. PHQ-9 score of 0 was used as the reference group. In addition, we performed a series of stratified analyses by age (45 years, 45 to 64 years, ≥65 years) and sex (male and female), obesity (BMI<30, BMI≥30), central obesity (WC<102/88cm for males/females, WC ≥102/88cm for males/females).

The synergistic effects of depression with obesity and central obesity on ischemic heart disease were estimated and expressed using the relative excess risk due to interaction (RERI) and the attributable proportion due to interaction (AP), adjusting for potential confounders. The formula for RERI is as follows: RR_{11}-RR_{01}-RR_{10}+1. AP is calculated as RERI/RR_{11}. RR_{11}, RR_{10}, and RR_{01} represent the logistic regression adjusted estimated RR of the covariate of depression and obesity, depression but not obesity, and obesity but not depression, respectively. Control subjects were neither depressed nor obese (RR_{00}). RERI and AP greater than 0 indicated synergistic effect between depression and BMI (or waist circumference). Hosmer and Lemeshow's methods were used to calculate the 95% CIs for the RERI and AP[37].

3. Results

The characteristics of those included 29,050 participants by depressive symptoms status were depicted in Table S2. The prevalence of depression symptoms (PHQ-9 scale ≥10) was 9.07%. There were significant differences in demographic characteristics between the depressive symptoms group and the non-depressive symptoms group. People with depressive symptoms were more likely to females, younger, smokers, drinkers, obese, subjects with hypertension, diabetes, less education, lower family income, lower work activity and recreational activity, lower total energy intake, higher caffeine intake. In addition, individuals with ischemic heart disease or its subtypes had a higher percentage in the depressive symptoms group.

Table 1 showed the results of logistic regression analyses. Depressive symptoms were positively associated with the risk of ischemic heart disease, coronary heart disease, angina, and heart attack, based on crude odds ratios (ORs) and 95% confidence intervals (CIs) for depressive symptom. When the PHQ scores were analyzed in the logistic regression as a continuous variable, the results were still significant. After adjustment for age and sex (model1), the results were similar to the crude model. Further adjustment in model2, there was significant correlation between depressive symptoms and ischemic and its subtypes (coronary heart diseases, heart attack and angina) with the multivariate-adjusted ORs (95% CIs) were 2.44(1.91,3.10), 2.32(1.67,3.23), 2.18(1.71,2.78), and 2.72(1.96,3.79), respectively. We used a forest map to show the results (Figure S1).

Table 1
Weighted odds ratios (95% confidence intervals) of ischemic heart disease coronary heart disease heart attack and anginas across depressive symptoms, NHANES 2007–2018 (N = 29050)

	Crude(N=29050)	Model1(N=29050)	Model2(N=22598)
Ischemic heart disease			
OR (95% CI)	2.10(1.75,2.53)	3.01(2.46,3.68)	2.44(1.91,3.10)
P-value	<0.001	<0.001	<0.001
Coronary heart disease			
OR (95% CI)	1.91(1.49,2.46)	2.80(2.12,3.69)	2.32(1.67,3.23)
P-value	<0.001	<0.001	<0.001
Heart attack			
OR (95% CI)	2.13(1.72,2.66)	2.93(2.35,3.66)	2.18(1.71,2.78)
P-value	<0.001	<0.001	<0.001
Angina			
OR (95% CI)	2.63(2.01,3.45)	3.31(2.49,4.40)	2.72(1.96,3.79)
P-value	<0.001	<0.001	<0.001

[a]Calculated using binary logistic regression. Model 1 adjusted for age, gender. Model 2 adjusted for age, gender, race/ethnicity, educational level, household income, caffeine intake, total energy intake, smoking, alcohol consumption, work activity, recreational activity, diabetes, hypertension and BMI.

Table S3 estimated associations between depressive symptoms and ischemic heart disease and its subtypes stratified by age, sex, obesity, and central obesity. In sex stratification, the positive associations between ischemic disease and depressive symptoms were significant in both male and female groups. In age-stratified analysis, we found no meaningful association between depressive symptoms and coronary heart disease in the 20-39 age group. In other age groups, depressive symptoms were positively associated with ischemic heart disease and its subtypes. In stratified analyses by obesity and central obesity, depressive symptoms were significantly associated with risk of ischemic heart disease and its subtypes in all levels.

Table 2 showed the combined effect of depression and obesity (BMI≥30) and central obesity (WC≥102/88cm for males/females) on ischemic heart disease. The combined effect of depression and central obesity was significantly greater than the sum of the individual effect. Compared with the reference group, the OR (95% CI) of only central obesity was 1.16 (0.93,1.46), and the OR (95% CI) of only depression was 1.88(1.24,2.88), and 3.15 (2.32,4.48) for it with both central obesity and depression. The RERI and AP with 95% CIs were 1.10(0.01,2.19) and 0.35(0.06,0.64) for depressive symptoms and central obesity. However, the additive interaction between depression and obesity was not significant. The RERI

and AP were 0.90(-0.31,2.12) and 0.26(-0.03,0.55), respectively. Table S4 described the synergic effect of depression and obesity on secondary outcomes, the three types of ischemic heart disease. Depressive symptoms and obesity were not significant for all three subtypes of ischemic heart disease. Depressive symptoms and central obesity could have a meaningful synergistic effect on heart attack. The RERI and AP were 0.84(-0.28, 1.96) and 0.31(0.00, 0.69), respectively. The synergistic effect was not significant when the outcome variables were coronary heart disease and angina pectoris.

Table 2
Synergic effect of depression and obesity on ischemic heart disease incidence, NHANES 2007–2018 (*N* = 29050)

	Incidence (%)	OR (95%CI)	RERI (95%CI)	AP (95%CI)
BMI category				
BMI<30.0kg/m^2 &Depression-	55.92	1	0.90(-0.31,2.12)	0.26(-0.03,0.55)
BMI ≥30.0 kg/m^2 & Depression-	34.91	1.33(1.13,1.57)		
BMI <30.0 kg/m^2 & Depression+	4.48	2.21(1.59,3.09)		
BMI ≥30.0 kg/m^2 & Depression+	4.69	3.49 (2.57,4.73)		
Waist category				
Central obesity- &Depression-	38.37	1	1.10(0.01,2.19) *	0.35(0.06,0.64) **
Central obesity+ &Depression-	55.46	1.16(0.93,1.46)		
Central obesity- & Depression+	2.78	1.88(1.24,2.85)		
Central obesity+ & Depression+	6.39	3.15(2.32,4.48)		
The model adjusted for age, gender, race/ethnicity, educational level, household income, caffeine intake, total energy intake, smoking, alcohol consumption, work activity, recreational activity diabetes and hypertension.				
*P < 0.05; **P < 0.01				

The dose-response relationships between PHQ-9 scores and ischemic heart disease, coronary heart disease, heart attack, and angina pectoris were shown in Figure 2. In the restricted cubic spline model, we found linear relationships between PHQ score with the risk of ischemic heart disease ($P_{\text{for linearity}}<0.0001$), coronary heart disease ($P_{\text{for linearity}}=0.015$), heart attack ($P_{\text{for linearity}}<0.0001$), and angina ($P_{\text{for linearity}}=0.001$).

4. Discussion

In this study, we used data including 29050 participants at least 20 years old from NHANES (2007–2018) database. We found that depressive symptoms were associated with a higher risk of ischemic heart disease and its subtypes, including coronary heart disease, angina pectoris and heart attack. when we did the dose-response relationship analysis, we found linear relationships between the PHQ-9 score with ischemic heart disease and its subtypes. Furthermore, we observed that the combined effect of depressive symptoms and central obesity increased the risk of ischemic heart disease. When we analyzed the other three subtypes of ischemic heart disease, we found that the synergistic effect of depressive symptoms and central obesity on heart attack was significant.

To date, several epidemiological studies have reported the combined effect of depression and obesity on ischemic heart disease. A 14-year follow-up MONICA–KORA Augsburg Cohort Study containing 6239 individuals indicated that the interaction between obesity and depression had a positive effect on the incidence of coronary heart disease. The interaction term between depression and obesity had an effect value of 1.73(95%CI 0.98–3.05) [38]. A cohort study detected the combined effects of three cardiovascular risk factors and lifelong depression on CVD events. The results pointed out the positive multiplicative interaction between BMI and depressive disorders was significant ($p = 0.031$)[28]. A finding of a study about longitudinal aging in Amsterdam were inconsistent with us. Interaction effects between depressive disorders and obesity were negative even not statistically significant (RERI (95% CI): -0.45 (-1.31–0.41))[29].

Several hypotheses explained the causal relationship among depressive disorders, obesity and the increased risk of ischemic heart disease. Depression and obesity may have overlapping pathophysiological pathways, so depression and obesity may amplify each other's pathophysiological mechanisms of atherosclerosis. First one is the dysfunction of the endocrine system. Depression and obesity are frequently accompanied by a chronic release of glucocorticoids, which lead to a slower response to their typical anti-inflammatory effects over time, whereafter, increasing the risk of cardiovascular disease[24, 39, 40]. Secondly, increased levels of inflammatory markers may mediate the progression of ischemic heart disease in individuals with depression or obesity [41, 42]. Both depression and obesity are associated with increased C-reactive protein, tumor necrosis factor-α, interleukin-1, and interleukin-6 levels.[23, 24, 43, 44]. Apart from overlapping physiological pathways, treatment nonadherence pathways perhaps be comprised, too[45, 46]. By means of interfering with or controlling the primary prevention of obesity, depression amplify the effect of obesity on atherosclerosis.

There were several strengths of this study. First of all, we analyzed the combined effects of depressive symptoms and obesity on three different subtypes of ischemic heart disease. In addition, in order to make our results more scientific, we used a a large number of national representative sample of adults in the US, as well as included and adjusted for known potential risk factors of ischemic heart disease. Besides, the additive interactions, relevant to public health and providing insight into mechanistic forms of interaction rather than statistical interaction, were applied to explore the combined effects of depressive symptoms and obesity in our study[47]. However, a few limitations should be considered and be solved in future research. It was difficult to obtain the causal inferences only through the cross-sectional design. In addition, this study might be subject to recall bias, hence certain data were based on self-reports. Though several potential confounding factors were controlled, we still cannot exclude the possibility of residual confusion caused by unmeasured confounding factors.

In conclusion, in this cross-sectional study, depressive symptoms were associated with a higher risk of ischemic heart disease in U.S. adults. There was also a synergistic effect between central obesity and depressive disorders. This manuscript mainly underscores that actively managing obesity is an efficient way to reduce the risk of ischemic heart disease in people suffering from depression.

Declarations

Data availability statement

The data that support the findings of this study are openly available from the National Health and Nutrition Examination Survey with the WEB LINK: https://www.cdc.gov/nchs/nhanes/index.htm .

Ethics approval

This work is not considered human subjects research as it relies on free, publicly available datasets (National Health and Nutrition Examination Survey) only, and is thus not subject to NCHS Research Ethics Review Board review.

Acknowledgments

This study utilized data from the National Health and Nutrition Examination Survey (NHANES). The authors would like to thank all contributors and participants in NHANES.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Role of the funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Notes on contributors

Shuo Liu: Conceptualization, Methodology, Software, Formal analysis, Writing - original draft, Writing - review and editing.

Jia Luo: Methodology, Software.

Tianhao Zhang: Methodology, Formal analysis.

Dongfeng Zhang: Software, Formal analysis.

Hua Zhang: Conceptualization, Methodology, Writing -review and editing.

All authors have read and agreed to the published version of the manuscript.

References

1. Global Health Estimates World Health Organization2020 [Available from: https://www.who.int/data/global-health-estimates.
2. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease: an update[J]. J Am Coll Cardiol. 2004,43(10):1731-7.
3. Wang DD, Hu FB. Dietary Fat and Risk of Cardiovascular Disease: Recent Controversies and Advances[J]. Annu Rev Nutr. 2017,37:423-46.
4. Yusuf S, Hawken S, Ôunpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study[J]. The Lancet. 2004,364(9438):937-52.
5. Rosengren A, Hawken S, Ôunpuu S, Sliwa K, Zubaid M, Almahmeed WA, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11 119 cases and 13 648 controls from 52 countries (the INTERHEART study): case-control study[J]. The Lancet. 2004,364(9438):953-62.
6. Yoshimasu K, Group TFHS. Relation of Type A Behavior Pattern and Job-Related Psychosocial Factors to Nonfatal Myocardial Infarction: A Case-Control Study of Japanese Male Workers and Women[J]. Psychosomatic Medicine. 2001,63(5):797-804.
7. Iso H, Date C, Yamamoto A, Toyoshima H, Tanabe N, Kikuchi S, et al. Perceived mental stress and mortality from cardiovascular disease among Japanese men and women: the Japan Collaborative Cohort Study for Evaluation of Cancer Risk Sponsored by Monbusho (JACC Study)[J]. Circulation. 2002,106(10):1229-36.
8. Hemingway H, Marmot M. Psychosocial factors in the aetiology and prognosis of coronary heart disease: systematic review of prospective cohort studies[J]. BMJ. 1999,318(7196):1460-7.
9. Sacker A, Bartley MJ, Frith D, Fitzpatrick RM, Marmot MG. The relationship between job strain and coronary heart disease: evidence from an english sample of the working male population[J].

Psychological medicine. 2001,31(2):279-90.

10. Matthews KA, Gump BB. Chronic work stress and marital dissolution increase risk of posttrial mortality in men from the Multiple Risk Factor Intervention Trial[J]. Archives of internal medicine. 2002,162(3):309-15.
11. Kivimäki M, Leino-Arjas P, Luukkonen R, Riihimäki H, Vahtera J, Kirjonen J. Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees[J]. Bmj. 2002,325(7369):857.
12. Stansfeld SA, Fuhrer R, Shipley MJ, Marmot MG. Psychological distress as a risk factor for coronary heart disease in the Whitehall II Study[J]. International journal of epidemiology. 2002,31(1):248-55.
13. Rosengren A, Tibblin G, Wilhelmsen L. Self-perceived psychological stress and incidence of coronary artery disease in middle-aged men[J]. The American journal of cardiology. 1991,68(11):1171-5.
14. WHO Depression fact sheet. 2018 [cited 2021 4/21]. Available from: http://www.who.int/en/news-room/fact-sheets/detail/depression.
15. Raison CL, Capuron L, Miller AH. Cytokines sing the blues: inflammation and the pathogenesis of depression[J]. Trends Immunol. 2006,27(1):24-31.
16. von Känel R. Platelet hyperactivity in clinical depression and the beneficial effect of antidepressant drug treatment: how strong is the evidence?[J]. Acta psychiatrica Scandinavica. 2004,110(3):163-77.
17. Cooper DC, Tomfohr LM, Milic MS, Natarajan L, Bardwell WA, Ziegler MG, et al. Depressed mood and flow-mediated dilation: a systematic review and meta-analysis[J]. Psychosom Med. 2011,73(5):360-9.
18. Paranthaman R, Greenstein AS, Burns AS, Cruickshank JK, Heagerty AM, Jackson A, et al. Vascular function in older adults with depressive disorder[J]. Biol Psychiatry. 2010,68(2):133-9.
19. van Sloten TT, Sigurdsson S, van Buchem MA, Phillips CL, Jonsson PV, Ding J, et al. Cerebral Small Vessel Disease and Association With Higher Incidence of Depressive Symptoms in a General Elderly Population: The AGES-Reykjavik Study[J]. The American journal of psychiatry. 2015,172(6):570-8.
20. Nicholson A, Kuper H, Hemingway H. Depression as an aetiologic and prognostic factor in coronary heart disease: a meta-analysis of 6362 events among 146 538 participants in 54 observational studies[J]. Eur Heart J. 2006,27(23):2763-74.
21. Lau DC, Dhillon B, Yan H, Szmitko PE, Verma S. Adipokines: molecular links between obesity and atheroslcerosis[J]. American journal of physiology Heart and circulatory physiology. 2005,288(5):H2031-41.
22. Rocha VZ, Libby P. Obesity, inflammation, and atherosclerosis[J]. Nature reviews Cardiology. 2009,6(6):399-409.
23. Ross R. Atherosclerosis--an inflammatory disease[J]. The New England journal of medicine. 1999,340(2):115-26.
24. Dhar AK, Barton DA. Depression and the Link with Cardiovascular Disease[J]. Front Psychiatry. 2016,7:33.

25. Hamieh N, Meneton P, Wiernik E, Limosin F, Zins M, Goldberg M, et al. Depression, treatable cardiovascular risk factors and incident cardiac events in the Gazel cohort[J]. Int J Cardiol. 2019,284:90-5.
26. Milaneschi Y, Simmons WK, van Rossum EFC, Penninx BW. Depression and obesity: evidence of shared biological mechanisms[J]. Mol Psychiatry. 2019,24(1):18-33.
27. Mathieu P, Lemieux I, Despres JP. Obesity, inflammation, and cardiovascular risk[J]. Clin Pharmacol Ther. 2010,87(4):407-16.
28. Polanka BM, Berntson J, Vrany EA, Stewart JC. Are Cardiovascular Risk Factors Stronger Predictors of Incident Cardiovascular Disease in U.S. Adults With Versus Without a History of Clinical Depression?[J]. Ann Behav Med. 2018,52(12):1036-45.
29. van Zutphen EM, Kok AAL, Rhebergen D, Huisman M, Beekman ATF. The joint effects of clinically relevant depressive symptoms and cardiovascular risk factors on incident cardiovascular disease among older adults in the community[J]. J Psychosom Res. 2021,149:110572.
30. Data. NHaNES. Centers for disease control and prevention (CDC) web site [Accessed 24 October 2020]. Available from: http://www.cdc.gov/NCHS/nhanes.htm.
31. Parsons VL, Moriarity C, Jonas K, Moore TF, Davis KE, Tompkins L. Design and estimation for the national health interview survey, 2006-2015[J]. Vital and health statistics Series 2, Data evaluation and methods research. 2014(165):1-53.
32. Manea L, Gilbody S, McMillan D. A diagnostic meta-analysis of the Patient Health Questionnaire-9 (PHQ-9) algorithm scoring method as a screen for depression[J]. General hospital psychiatry. 2015,37(1):67-75.
33. CDC/NCHS. NHANES - Questionnaires, Datasets, and Related Documentation 2018 [Available from: https://wwwn.cdc.gov/nchs/nhanes/Default.aspx.
34. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement[J]. Circulation. 2005,112(17):2735-52.
35. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies[J]. Lancet (London, England). 2004,363(9403):157-63.
36. 2021 ICD-10-CM codes for ischemic heart diseases (I20-I25) [Accessed 28 October 2020]. Available from: https://icdlist.com/icd-10/index/ischemic-heart-diseases-i20-i25.
37. Hosmer DW, Lemeshow S. Confidence interval estimation of interaction[J]. Epidemiology (Cambridge, Mass). 1992,3(5):452-6.
38. Ladwig KH, Marten-Mittag B, Löwel H, Döring A, Wichmann HE. Synergistic effects of depressed mood and obesity on long-term cardiovascular risks in 1510 obese men and women: results from the MONICA-KORA Augsburg Cohort Study 1984-1998[J]. International journal of obesity (2005). 2006,30(9):1408-14.
39. Penninx BW. Depression and cardiovascular disease: Epidemiological evidence on their linking mechanisms[J]. Neurosci Biobehav Rev. 2017,74(Pt B):277-86.

40. Piché ME, Tchernof A, Després JP. Obesity Phenotypes, Diabetes, and Cardiovascular Diseases[J]. Circ Res. 2020,126(11):1477-500.
41. Iyengar NM, Gucalp A, Dannenberg AJ, Hudis CA. Obesity and Cancer Mechanisms: Tumor Microenvironment and Inflammation[J]. Journal of clinical oncology : official journal of the American Society of Clinical Oncology. 2016,34(35):4270-6.
42. Beurel E, Toups M, Nemeroff CB. The Bidirectional Relationship of Depression and Inflammation: Double Trouble[J]. Neuron. 2020,107(2):234-56.
43. Ortega FB, Lavie CJ, Blair SN. Obesity and Cardiovascular Disease[J]. Circ Res. 2016,118(11):1752-70.
44. Wang W, Jiang W, Hou L, Duan H, Wu Y, Xu C, et al. Weighted gene co-expression network analysis of expression data of monozygotic twins identifies specific modules and hub genes related to BMI[J]. BMC Genomics. 2017,18(1):872.
45. Berntson J, Stewart KR, Vrany E, Khambaty T, Stewart JC. Depressive symptoms and self-reported adherence to medical recommendations to prevent cardiovascular disease: NHANES 2005-2010[J]. Soc Sci Med. 2015,138:74-81.
46. Ye S, Muntner P, Shimbo D, Judd SE, Richman J, Davidson KW, et al. Behavioral mechanisms, elevated depressive symptoms, and the risk for myocardial infarction or death in individuals with coronary heart disease: the REGARDS (Reason for Geographic and Racial Differences in Stroke) study[J]. J Am Coll Cardiol. 2013,61(6):622-30.
47. Qiu H, Yu IT, Wang XR, Fu ZM, Tse SL. [Study on the interaction under logistic regression modeling][J]. Zhonghua liu xing bing xue za zhi = Zhonghua liuxingbingxue zazhi. 2008,29(9):934-7.

Figures

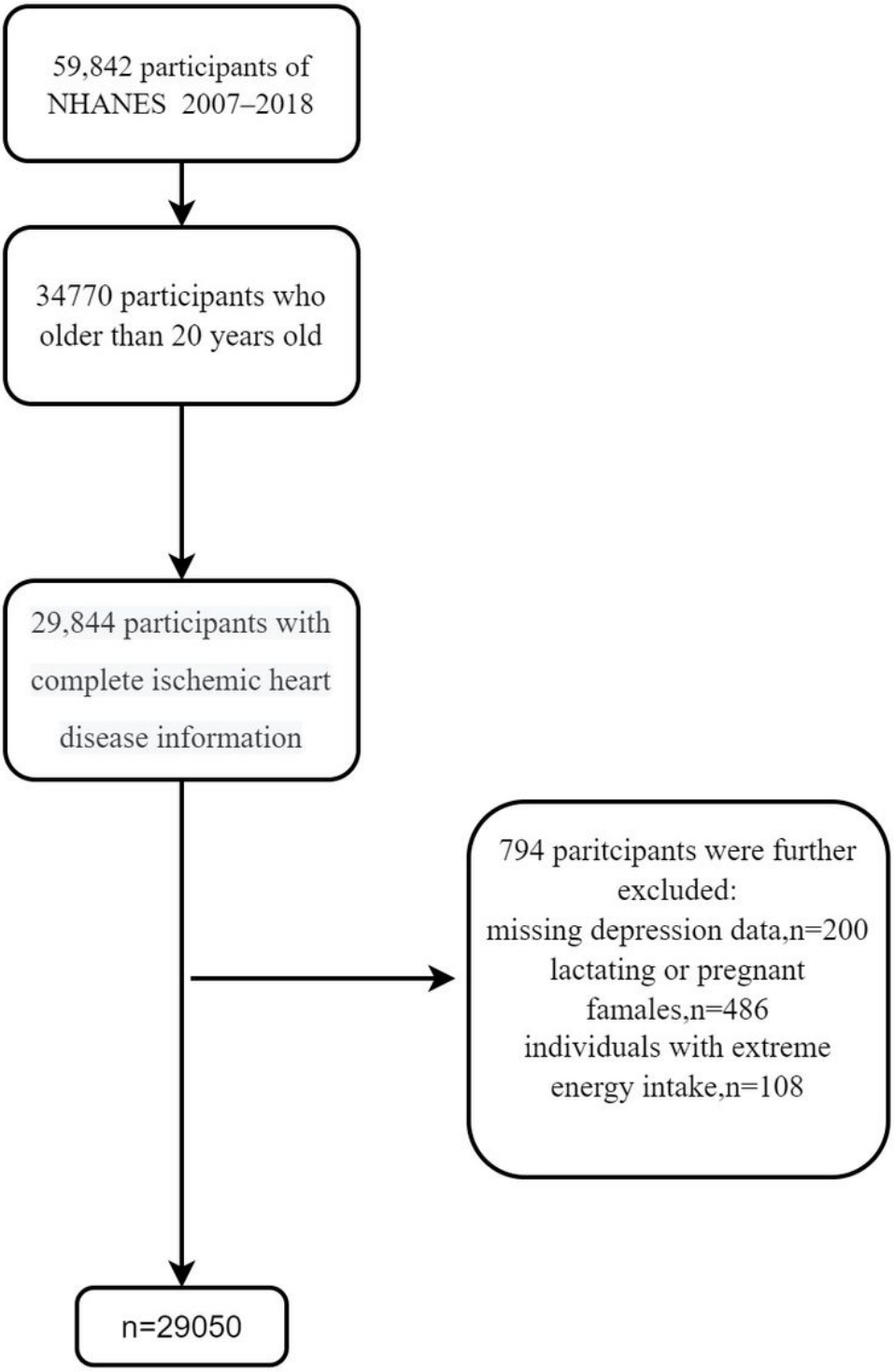

Figure 1

Flow diagram of the selection of eligible participants, NHANES 2007–2018.

Figure 2

The dose-response relationships between PHQ scores and ischemic heart disease, coronary heart disease, heart attack, and angina pectoris. The solid line and dashed line represent the estimated ORs and its 95%CI. OR, odds ratio. CI, confidence intervals. A, B, C, D represent the outcome variables are ischemic heart disease, coronary heart disease, heart attack, and angina pectoris, respectively.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryinformation.pdf