The Association between BMI and Osteoarthritis in Adults

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Research Article

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Abstract
Objectives: The prevalence of obesity-related symptomatic OA has been found to increase. We investigated the relationship between BMI and osteoarthritis in 14,058 20-85 year-old participants from the National Health and Nutrition Examination Survey (NHANES).

Methods: To estimate the association between BMI and osteoarthritis, multivariate logistic regression analyses were conducted. Fitted smoothing curves.

Results: After adjusting for other confounding factors, we found that BMI was positively correlated with osteoarthritis. On subgroup analyses, stratified by sex and race/ethnicity, the positive correlation between BMI and Osteoarthritis in men and women, as well as in whites, blacks, and Mexican Americans, still exists.

Conclusions: Our study revealed a positive relationship between BMI and Osteoarthritis in most adults.

Keywords: BMI, Osteoarthritis, adults, NHANES
Osteoarthritis (OA) is the most common type of joint disease and the main cause of pain, restricted mobility, and decreased function, especially in the elderly. It is estimated that approximately 25% of people older than 55 have persistent knee pain, and 10% of them report painful disabling knee OA[1]. The development of OA is related to genetics, age, gender, obesity, previous knee injuries, occupational factors (for example, kneeling and squatting), physical activity, and knee dislocation[2].

Obesity is one of the biggest health risks facing the world today. In recent decades, the worldwide prevalence of obesity has been increasing at an alarming rate, and the tendency to be accompanied by multiple comorbidities is also increasing. In addition, people in developed countries live longer[3]. As obesity gradually increases in the elderly, it is expected that the prevalence of obesity-related symptomatic knee OA will increase, and it may become a major global public health problem.

Worldwide, with the increase in life expectancy, the prevention and treatment of osteoarthritis have become two increasingly important public health issues, which means that there is an urgent need to find more effective methods to reduce the related economic burden[4]. Here, we conducted a cross-sectional study using a large database from the National Health and Nutrition Examination Survey (NHANES) to estimate the association between BMI and osteoarthritis in adults.

Materials & methods

Statement of Ethics

The study was approved by the Ethical Review Committee of the National Center for Health Statistics and received written informed consent from each participant, and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments and comparable ethical standards.

Study Population

NHANES is a representative survey of the national population of the United States (US), using a complex, multi-stage, probability sampling design to provide a large amount of information about the nutrition and health of the general population of the United States[5].

All data were obtained from the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2006. NHANES was a cross-sectional study of noninstitutionalized US citizens and was conducted by the Centers for Disease Control and Prevention (CDC) and the National Center for Health Statistics (NCHS). NHANES database included personal data including demographic information, past medical history and laboratory data. The
participants' information was collected by a household interview and a subsequent physical examination. All of the study protocol, consent documents and relevant information were detailed on the NHANES website. The NHANES study protocol was conducted according to the NCHS Institutional Review Board (IRB). Before data collection and the health examinations, all informed consents had been obtained. All the experimental protocols were approved by NCHS IRB.

Our analysis is based on 1999-2006 data, which represents the three cycles of NHANES. Excluding participants with missing BMI data (n = 6366), osteoarthritis data (n = 19957), cancer participants (n = 1093), a total of 14,058 participants aged 20-85 were included in our analysis.

**Variables**

The exposure variable of this study is BMI. Weight and height are measured using standardized procedures[6]. The outcome variable is osteoarthritis. As part of the NHANES project, the diagnosis of arthritis is based on a medical condition questionnaire collected through interviews. The following categorical variables are included as covariates in our analysis: gender, race/ethnicity, ethnicity, education level, smoking history, ratio of household income to poverty, vigorous recreational activities, drinking, high blood pressure, diabetes, waist circumference. Detailed information about BMI, osteoarthritis, and covariates are publicly available at [http://www.cdc.gov/nchs/nhanes/](http://www.cdc.gov/nchs/nhanes/). All measurements were standardized according to the guidelines that were recommended by the Centers for Disease Control and Prevention (CDC).

**Statistical Analysis**

All estimates are calculated based on NHANES sample weights. After adjusting for potential confounding factors, weighted multiple regression analysis was used to estimate the independent relationship between BMI and osteoarthritis. The weighted generalized additive model and smooth curve fitting were used to solve the nonlinear problems of BMI and osteoarthritis in subgroup analysis.

Categorical variables are expressed as frequency or percentage. Continuous variables are expressed as mean ± standard deviation. Perform a weighted linear regression model (continuous variable) and a weighted chi-square test (categorical variable) to calculate the difference between different groups. P < 0.05 was considered statistically significant. All analyses were performed using Empower software (www.empowerstats.com; X&Y Solutions, Inc., Boston MA) and R version 3.4.3 ([http://www.R-project.org](http://www.R-project.org), The R Foundation).

**Research ethics**

NHANES study protocols were approved by the research ethics review board of the National Center for Health
Statistics. Methods were carried out following the STROBE statement. Written informed consents were obtained from all participants in the study, and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments and comparable ethical standards.

Results

Study sample

The characteristics of the samples are shown in Table 1, and the relevant characteristics between the osteoarthritis group and the non-osteoarthritis group are summarized as follows. Compared with the non-arthritis group, the arthritis group is older (mean age 43.16 ± 17.17 years and 64.26 ± 14.19 years), and the proportion of women is higher than that of men (50.43% and 63.96%). Race, education level, smoking history, ratio of family income to poverty, strenuous recreational activities, drinking, high blood pressure, diabetes, waist circumference, and BMI were also significantly different between the two groups (P <0.05).

Multiple regression model

The results of the multivariate regression analyses are presented in Table 2. The influence of the correlation between BMI and osteoarthritis is listed in Table 2. In the unadjusted model, we observed a positive correlation between BMI and osteoarthritis. Similar results were found in Model 2 (adjusted for age, gender, race/ethnicity) and Model 3 (fully adjusted model) (OR = 1.05, 95%CI: 1.04, 1.07, P <0.001). According to the quartiles of BMI, the trend test between them is still significant (P = 0.0061).

Subgroup analyses

In the subgroup analysis stratified by gender and race/ethnicity, as shown in Table 3, males (OR = 1.06, 95%CI: 1.03, 1.10, P <0.001) and females (OR = 1.06 95%CI: 1.03, 1.08, P=0.001), as well as whites (OR= 1.05, 95%CI: 1.03, 1.08, P <0.001) and blacks (OR = 1.06, 95%CI: 1.02, 1.10, P <0.001) and Mexican Americans People (OR =1.06 95%CI:1.00, 1.11 P = 0.0385), but not other races/ethnicities.

We also performed a weighted generalized additive model and smooth curve fitting to evaluate the association between them (Figures 2, 3).

Discussion

In this study, we used these representative samples from NHANES 2001-2006 to assess the association between BMI and osteoarthritis in adults. The results showed that BMI was positively correlated with osteoarthritis.
Obesity is one of the most important modifiable risk factors for the occurrence[7-12] and progression[7, 12-14] of knee OA. Some people believe that being overweight will increase the mechanical load on the joints, leading to increased cartilage degradation and subsequent failure of the entire joint[15]. There is evidence that excessive weight may reduce the biomechanical load placed on weight-bearing joints. Obesity may also cause metabolic dysfunction and joint damage by stimulating the known metabolic homeostasis regulator adipokines, which is reasonable[16, 17]. This may partly explain the different association between obesity and the incidence of OA in weight-bearing joints and non-weight-bearing joints (such as hand OA) [18, 19]. In many RCTs of weight-bearing joint OA, weight loss has been shown to have a significant clinical effect in the treatment of OA[20]. Another suggested mechanism is regulation by metabolic and hormonal factors, which are detrimental to the health of joint tissues[15]. In the Framingham knee OA study, it was found that a weight loss of about 5.1 kg over a 10-year period can reduce the risk of knee OA by 54% (odds ratio [OR] 0.46, 95% confidence interval [95% CI] 0.24 – 0.86) Among women[21]. (As shown in Figure 1)

In summary, obesity is a common risk factor associated with many diseases, including knee OA. Although effective modification is challenging, it is one of the few risk factors that can be modified. The benefits of preventing obesity in the general population are huge, especially in the Western world where obesity is very common. For example, if this risk factor is eliminated, approximately half of symptomatic knee OA will be prevented in the United States.

On the other hand, osteoarthritis (OA) is a degenerative disease of the joints that occurs when the cartilage or cushion between the joints ruptures causing pain, swelling, and stiffness. OA is the most common chronic joint disease, affecting more than 30 million American adults. Some risk factors include joint damage or overuse, gender, age, obesity, race, and genetics (CDC, 2017). It is very common among the elderly. Symptoms include pain, swelling, and stiffness. The diagnosis of OA involves physical examination of the joints and testing of the range of motion. Joint aspirations, X-rays, or magnetic resonance imaging (MRI) are usually used to confirm the diagnosis. Several studies have found that the risk of developing OA increases with age and/or body mass index (BMI)[2, 22, 23]. Compared with men, women always have a higher risk of OA [24, 25]. Obesity is also a major risk factor for OA [26]. Many studies have observed a positive correlation between BMI and OA [27-30]. The pathogenesis of OA is related to excessive joint load and changes in biomechanical patterns, as well as hormonal and cytokine disorders[31].

This study includes a representative sample of a multi-ethnic population to better generalize the American population, and this large sample size allows us to conduct further subgroup analysis. This is the biggest
advantage of this research. There are some restrictions. First, due to the nature of the cross-sectional study, we cannot determine whether BMI affects the changes in osteoarthritis over time, and cannot assess causality. Secondly, we excluded participants with cancer or malignant tumors, because these special populations have a great influence on BMI and osteoarthritis. Therefore, the conclusions in this study cannot be applied to them. Third, we did not adjust other variables. Therefore, the bias caused by other potential confounding factors cannot be ruled out.

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**Figure legends**

Figure 1, The association between BMI and osteoarthritis. The solid arc line represents a smooth curve fit between the variables. The blue bar represents the 95% confidence interval of the fit. The age, gender, race, education level, smoking history, ratio of family income to poverty, strenuous recreational activities, drinking, high blood pressure, diabetes, and waist circumference were adjusted.

Figure 2
The association between Body mass index and osteoarthritis stratified by sex. Age, race, education level, smoking history, ratio of household income to poverty, strenuous recreational activities, drinking, high blood pressure, diabetes, waist circumference were adjusted.

Figure 3
The association between Body mass index and osteoarthritis stratified by race/ethnicity. Age, gender, education level, smoking history, ratio of household income to poverty, strenuous recreational activities, drinking, high blood pressure, diabetes, waist circumference were adjusted.
Figure 1

The association between BMI and osteoarthritis. The solid arc line represents a smooth curve fit between the variables. The blue bar represents the 95% confidence interval of the fit. The age, gender, race, education level, smoking history, ratio of family income to poverty, strenuous recreational activities, drinking, high blood pressure, diabetes, and waist circumference were adjusted.
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Figure 3

The association between Body mass index and osteoarthritis stratified by race/ethnicity. Age, gender, education level, smoking history, ratio of household income to poverty, strenuous recreational activities, drinking, high blood pressure, diabetes, waist circumference were adjusted.

Supplementary Files

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- Table1.pdf
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