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Positive Association between Hearing Impairment and Obesity in Adults Aged 20 Years and Older in US: Data from the 2015-2016 National Health and Nutrition Survey (NHANES)

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Abstract

Background: People are exposed to noise sources, diseases or accidents in their daily work and life, resulting in different degrees of hearing damage. On the basis of previous studies on hearing impairment caused by obesity, we put forward the opposite hypothesis. What is the relationship between hearing impairment and the incidence of obesity?

Objective: We analyzed the relationship between hearing status and obesity in order to make some suggestions for people who are obese due to hearing impairment.

Materials and methods: In this study, 4391 adults aged 20 and above were randomly selected from the 2015-2016 National Health and Nutrition Survey (NHANES), including 2149 males and 2242 females, with an average age of 49.43 ± 17.590 The count variables were tested by Chi-square test, and measurement variables were tested by Kruskal-Wallis rank sum test. Hearing impairment as an independent variable, obesity as a dependent variable. Binary Logistic regression analysis was performed on the above variables.

Results: After excluding confounding factors, the Odds Ratio (OR) of hearing impairment and obesity was 1.100 (95%CI:1.030-1.174, P<0.01).

Conclusion: Hearing impairment is a risk factor for obesity. The higher the degree of hearing impairment, the higher the risk of obesity.

Keywords: Hearing impairment; Hearing status; Adult; Obesity

Abbreviations: NHANES: National Health and Nutritional Examination Survey; CAPI: Computer-Assisted Personal Interviewing; OR: Odds Ratio; CI: Confidence Interval; P: P-Value; U. S.: The United States of America; AUQ: Hearing Measurement Questionnaire; BMI: Body Mass Index; SPSS: Statistical Package for Social Sciences

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Introduction

People will be exposed to noise sources, diseases or accidents in their daily work and life, resulting in different degrees of hearing impairment. Among many factors, obesity caused by abnormal fat or excessive accumulation, as a health risk, is often one of the most easily overlooked factors of hearing impairment. Studies have shown that obesity has a negative impact on vascular function, especially on highly vascularized organs such as the auditory system, which may lead to hearing impairment or even loss. A potential mechanism of obesity-induced hearing loss is

that excessive adipose tissue causes pressure on the capillary wall, leading to vasoconstriction of the inner ear and damage to the inner ear system, which is manifested as human hearing loss [1]. On the basis of previous studies on hearing impairment caused by obesity, we put forward the opposite hypothesis. What is the relationship between hearing impairment and the incidence of obesity? This may be because hearing impairment can affect people's physical activity, mental health and eating habits, and ultimately lead to obesity or not obesity. Therefore, we analyzed the relationship between hearing impairment and obesity, and obtained the relationship between independent variables and dependent variables. From the perspective of the auditory sensory system, we aim to return the research recommendations to body obesity.

Materials and Methods

Population

In **Figure 1** The National Health and Nutrition Survey (NHANES) is a well-known public database in the United States. It is a population-based cross-sectional survey that combines interviews and physical examinations to collect health and nutritional status information for adults and children in the United States. [2] The NHANES protocol was endorsed by the Research Ethics Review Committee of the National Center for Health Statistics; all adult subjects provided written consent notices. [3] This study extracted data from three aspects of the 2015-2016 National Health and Nutrition Examination Survey (NHANES), including: Demography, hearing impairment, and Body Mass Index (BMI). After eliminating invalid data (missing, blank), a total of 4391 samples were included (including 2149 males and 2242 females, with an average age of 49.43 ± 17.590). In the process of research and design, the process of data screening is shown in the following figure.

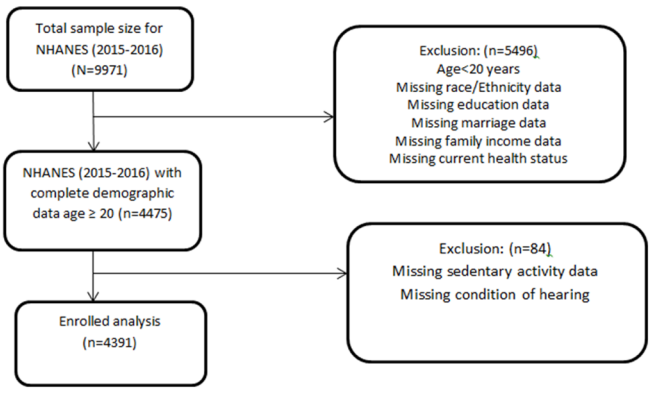

Figure 1 Data screening flowchart.

Hearing impairment assessment

The Hearing Measurement Questionnaire (AUQ) provides interview data on self-reported hearing status, tinnitus, history of hearing screening, use of hearing aids, use of hearing aids, and risk factors for hearing loss. We selected the 'general hearing status (AUQ054)' to assess hearing impairment. Hearing status was assigned as a count variable. 1=excellent; 2=good; 3=a little trouble; 4=moderate hearing trouble; 5=a lot of trouble; 6=deaf.

Obesity assessment

Body Mass Index (BMI) is a common index to measure the degree of obesity and health in the world. Body Mass Index (BMI) from NHANES body measurement data was included in this study. Body mass index data are collected by trained health technicians at the Mobile Inspection Centre (MEC) and recorded with the assistance of a recorder. Among them, health technicians need to receive a two-day training. Body Mass Index (BMI) is the data obtained after calculation. The calculation method is to divide the weight in kilograms by the square of height in meters (kg/m^2), and then rounded to one decimal point. According to the purpose of the study, we divided BMI into four standard categories in the original data: Lean (≤ 18.9 kg/m^2), normal (19.0-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) and obesity (≥ 30.0 kg/m^2) [4]. Body Mass Index (BMI) ≥ 30.0 kg/m^2 was used as the standard of obesity, and obesity was assigned as a count variable: 1=obesity; 2=not obesity.There are long standing computational models of CAs [17,18]. Here the system represents a set of neurons that have particular parameters. When sufficient activity is sent into the system, the CA ignites, then follows a Snoopy curve of activation. That is the system initially has a burst of activity, then the activity gradually decreases, until it can no longer support the reverberating activity and then the activity, collapses to below the baseline activity. (It is called a Snoopy curve because a plot of neurons firing by time looks something like Snoopy lying on his dog house.) Unfortunately, these models have not been simulated in spiking neurons.

Covariates

The covariates of this study include gender, age, race, education level, marital status, income poverty ratio, current health status and sedentary behavior. Gender is divided into male and female; age is divided into 20-39 years old, 40-59 years old and ≥ 60 years old; race is divided into Mexican Americans, other Hispanics, non-Hispanic whites, non-Hispanic blacks, non-Hispanic Asians and other races; the education level is divided into high school education below, high school education and high school education above; marital status is divided into cohabitation, married living alone (widowed, divorced and separated) and unmarried; the income poverty ratio is calculated as the ratio of household income to the poverty criterion of the survey year. In this study, we divided the income poverty ratio into poverty (<1.3) and middle income (≥ 1.3) [5]; the current health status is divided into excellent, good and poor; sedentary behaviour is divided into 0-299 min, 300-599 min, 600-899 min and 900-1200 min.

Quality control

Trained interviewers use the Computer-Aided Personal Interview System (CAPI) to ask questions in the Mobile Examination Center (MEC). The personal interview system is programmed with built-in consistency checks, which can effectively reduce data entry

errors. At the same time, regular quality control inspections were conducted on the collected data, and training was conducted on the interviewer's feedback questions to ensure the reliability and validity of the data.

Statistical analysis

We used Microsoft Excel 2010 to process the raw data collected by NHANES, including the exclusion of missing and useless (rejected, unknown) items. The final database is: Demographics of adults aged 20 and above in the United States, hearing impairment and obesity information. According to the purpose of the study, we analyzed the descriptive characteristics of hearing impairment. Chi-square test was used for univariate analysis of count variables, and Kruskal-Wallis rank sum test was used for univariate analysis of measurement variables. Variables with statistical significance in univariate analysis were included in binary logistic regression analysis. Binary logistic regression model was used to analyze the effect of hearing impairment on obesity was analyzed. A-entry=0.05 and a-exit=0.10 were used to select and exclude variables.

When analyzing the relationship between hearing impairment and obesity, we use hearing impairment as an independent variable and obesity as a dependent variable. In order to exclude the influence of confounding variables, we established the following model: Model I: no adjustment of variables. Model II: based on model I, demographic variables (gender, age, race, marital status and current health status) were added to adjust. Model III: based on model II, sedentary behavior was added to adjust.

Statistical Product and Service Solutions (SPSS 26.0) was used to analyze the data, and a two-sided test P value of less than 0.05 was defined as statistically significant.

Results

Data analysis

Demographic characteristics analysis: This study included a total of 4391 American adults aged 20 and above from 2015 to 2016 in NHANES, and the participants had completed the collection of demographic data. Participants included 2149 males and 2242 females, with an average age of 49.43 ± 17.590. After analysis, we found that the demographic characteristics of hear impairment, gender, age, race, education level, marital status, current health status (all P<0.001) and income to poverty (P=0.016) were statistically significant, sedentary behavior (P=0.053) were not found statistical differences **(Table 1)**.

Table 1: Demographic characteristics of hear impairment in Americans aged 20 years and older.

Characteristics	Sample capacity	Excellent	Good	A little trouble	Moderate trouble	A lot of trouble	Deaf	Test statistics	P
	N=4391	n=1585	n=1768	n=633	n=276	n=120	n=9		
Gender								58.345[a]	< 0.001 ***
Male	2149 (100.0)	718 (33.4)	849 (39.5)	318 (14.8)	189 (8.8)	72 (3.4)	3 (0.1)		
Female	2242 (100.0)	867 (38.7)	919 (41.0)	315 (14.0)	87 (3.9)	48 (2.1)	6 (0.3)		
Age group (years)								633.804[b]	< 0.001 ***
20-39	1485 (100.0)	753 (50.7)	589 (39.7)	106 (7.1)	28 (1.9)	9 (0.6)	0 (0.0)		
40-59	1455 (100.0)	$ 15 (35.4)	656 (45.1)	193 (13.3)	72 (4.9)	19 (1.3)	0 (0.0)		
≥ 60	1451 (100.0)	317 (21.8)	523 (36.0)	334 (23.0)	176 (12.1)	92 (6.3)	9 (0.6)		
Race								212.950[a]	< 0.001 ***
Mexican American	758 (100.0)	245 (32.3)	347 (45.8)	95 (12.5)	48 (6.3)	22 (2.9)	1 (0.1)		
Other Hispanic	559 (100.0)	205 (36.7)	228 (40.8)	75 (13.4)	37 (6.6)	14 (2.5)	1 (0.1)		
Non-Hispanic white	1555 (100.0)	436 (28.0)	603 (38.8)	303 (19.5)	142 (9.1)	64 (4.1)	7 (0.5)		
Non-Hispanic black	902 (100.0)	414 (45.9)	350 (38.8)	100 (11.1)	25 (2.8)	13 (1.4)	0 (0.0)		
Non-Hispanic Asian	455 (100.0)	222 (48.8)	180 (39.6)	37 (8.1)	11 (2.4)	4 (0.9)	1 (0.2)		
Other	162 (100.0)	63 (38.9)	60 (37.0)	23 (14.2)	13 (8.0)	3 (1.9)	0 (0.0)		

Education								66.714b	< 0.001 ***
Below high school	981 (100.0)	266 (27.1)	422 (43.0)	157 (16.0)	95 (9.7)	38 (3.9)	3 (0.3)		
High school	974 (100.0)	337 (34.6)	398 (40.9)	153 (15.7)	57 (5.9)	28 (2.9)	1 (0.1)		
Post high school	2436 (100.0)	982 (40.3)	948 (38.9)	323 (13.3)	124 (5.1)	54 (2.2)	5 (0.2)		
Marital statues								131.834[a]	< 0.001 ***
Cohabitation	2659 (100.0)	962 (36.2)	1097 (41.3)	387 (14.6)	151 (5.7)	59 (2.2)	3 (0.1)		
Married living alone	933 (100.0)	254 (27.2)	360 (38.6)	172 (18.4)	95 (10.2)	47 (5.0)	5 (0.5)		
Never married	799 (100.0)	369 (46.2)	311 (38.9)	74 (9.3)	30 (3.8)	14 (1.8)	1 (0.1)		
Income to poverty								13.888[b]	0.016
Impoverished	1407 (100.0)	490 (34.8)	565 (40.2)	204 (14.5)	101 (7.2)	43 (3.1)	4 (0.3)		
Moderate income	2984 (100.0)	1095 (36.7)	1203 (40.3)	429 (14.4)	175 (5.9)	77 (2.6)	5 (0.2)		
Current health status								149.426[b]	< 0.001 ***
Good	3298 (100.0)	1319 (40.0)	1323 (40.1)	416 (12.6)	166 (5.0)	67 (2.0)	7 (0.2)		
Fair	931 (100.0)	234 (25.1)	390 (41.9)	177 (19.0)	91 (9.8)	38 (4.1)	1 (0.1)		
Bad	162 (100.0)	32 (19.8)	55 (34.0)	40 (24.7)	19 (11.7)	15 (9.3)	1 (0.6)		
Sedentary behavior (min)								10.905[b]	0.053
0-299	1602 (100.0)	583 (36.4)	667 (41.6)	210 (13.1)	102 (6.4)	39 (2.4)	1 (0.1)		
300-599	1956 (100.0)	687 (35.1)	777 (39.7)	311 (15.9)	122 (6.2)	56 (2.9)	3 (0.2)		
600-899	759 (100.0)	288 (37.9)	298 (39.3)	104 (13.7)	42 (5.5)	22 (2.9)	5 (0.7)		
900-1200	74 (100.0)	27 (36.5)	26 (35.1)	8 (10.8)	10 (13.5)	3 (4.1)	0 (0.0)		
BMI (kg /m²)								33.456[b]	< 0.001 ***
≤ 18.9	86 (100.0)	42 (48.8)	33 (38.4)	6 (7.0)	4 (4.7)	1 (1.2)	0 (0.0)		
19.0-24.9	1094 (100.0)	457 (41.8)	424 (38.8)	132 (12.1)	57 (5.2)	21 (1.9)	3 (0.3)		
25.0-29.9	1405 (100.0)	494 (35.2)	566 (40.3)	209 (14.9)	89 (6.3)	42 (3.0)	5 (0.4)		
≥ 30.0	1806 (100.0)	592 (32.8)	745 (41.3)	286 (15.8)	126 (7.0)	56 (3.1)	1 (0.1)		

Note: (a)Chi-square test; (b) Kruskal-Wallis-test; (c) *P ≤ 0.05; (d) **P ≤ 0.01; (e)***P ≤ 0.001

Binary logistic regression analysis

The relationship between hearing impairment and obesity: In this study, in the statistical test of hearing impairment and obesity, the variables of gender, age, race, education level, marital status, current health status and income to poverty were statistically significant. Therefore, the above variables are included in the binary logistic regression model for analysis. In order to eliminate the influence of confounding variables, we established the following model: Model I: No adjustment of variables, OR=1.114, 95%CI: 1.050-1.181. Model II: On the basis of Model I, demographic variables (gender, age, race, education level, marital status and income to poverty) were added to adjust, OR=1.109, 95%CI: 1.039-1.183. Model III: On the basis of Model II, sedentary behavior was added to adjust, OR=1.100, 95% CI:1.030-1.174 **(Table 2)**. The results show that after adjusting for confounding factors, hearing impairment is a risk factor for obesity. The more severe the hearing impairment, the more likely it is to become obese.

Table 2: Binary Logistic regression analysis results of hearing impairment and obesity.

Mode	b	SE	Wald	P	OR(95%CI)
Ia	0.108	0.03	12.953	<0.001***	1.114(1.050-1.181)
IIb	0.103	0.033	9.629	0.002	1.109(1.039-1.183)
IIIc	0.095	0.033	8.064	0.005	1.100(1.030-1.174)

Note: (a) Only adjusts the work of the independent variable exposed to noise; (b) According to the independent variables in Model I, demographic variables (gender, age, race, education level, marital status and income to poverty) were added for adjustment; (c) According to the independent variables in Model II, sedentary behavior was added for adjustment.

Discussion

Through the logistic regression analysis of NHANES 2015-2016 data, we found that hearing impairment is associated with an increased risk of obesity. These findings come from the results of binary logistic regression analysis. Therefore, we discuss the relationship between hearing impairment and obesity in the following sections. In the current study, the direct causes of obesity caused by unhealthy living habits such as excessive drinking, smoking, insufficient exercise and overeating have been identified or verified [6]. Other studies have shown that infrequent or lack of exercise and personal education level are the determinants of obesity [7-12]. Kadouh and Acosta's research shows that obesity is a multi-factor interaction that leads to energy imbalance and weight gain [13,14]. Therefore, we believe that the decisive factors leading to obesity include biological factors, environmental factors and behavioral factors. Hearing impairment can be classified as obesity caused by biological factors. Studies have shown that the elderly with hearing impairment, especially those with higher levels of hearing impairment, have lower levels of physical activity and longer sedentary behaviour [15]. Gispen et al. found that moderate or greater hearing loss was independently associated with decreased physical activity levels in the sample of the elderly in the United States [16]. From this point of view, people with hearing impairment have less enthusiasm and initiative to participate in physical activity, which may lead to slow body metabolism, fat accumulation and increase the risk of obesity. In addition, the association between hearing impairment and obesity may also be: Hearing impaired people accept distorted sounds, resulting in poor language comprehension and communication skills, forming a psychological state of social isolation, and then reluctant to participate in physical activity or seek psychological comfort by overeating, eventually making the body obese. The results of this study suggest that the more serious the degree of hearing impairment, the greater the possibility of obesity. We explain this result as hearing impairment can affect mental state and cognitive function, so that people's physical activity and eating behavior have a negative impact, increasing the possibility of obesity [17-19].

Research limitations

There are several limitations in this study: (a) This study only extracted data from 2015-2016, so the collected data span is relatively short. In future research, we plan to extract more years of data to further verify the conclusions of this study. (b) The causes of sedentary activity and obesity are diverse, when we exclude the influence of confounding factors, we only consider excluding demographics (gender, age, race, education level, marital status, income poverty ratio and current health status), and cannot exclude the influence of more confounding factors. measurement in the United States, so the results and conclusions of the study can better explain the problems existing in the American population, and cannot explain obesity problems in other countries and regions of the world.

Conclusion

The results of this study show that hearing impairment is positively correlated with obesity. The more severe the hearing loss, the greater the risk of obesity.

Declarations

Ethics approval and consent to participate

All procedures performed in the study were in accordance with the Declaration of Helsinki. The study protocols for NHANES were approved by the National Center for Health Statistics (NCHS) Research Ethics Review Board (Protocol#2017–1). All adult participants provided written notification of consent before participating in the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are available in then [NHANES] repository, [NHANES Questionnaires, Datasets and Related Documentation (cdc.gov)]. Raw data supporting the obtained results are available at the corresponding author.

Author contribution

Yiwen Cao and Rui Feng conceived and designed the study. Yiwen Cao and Jipeng Zhang organized the database, performed the statistical analysis and wrote the manuscript. Linguist Rui Feng confirmed the accuracy of the written language. Yiwen Cao and Rui Feng revised the manuscript. All authors edited, revised, and certified the final version of this manuscript.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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