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Evaluating the Relationship between Body Mass Index and Heart Disease: An Analysis of Smoking's Modifying Role

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Abstract

Background and Aims:
Heart disease is a global health concern, with risk factors such as age, sex, diabetes, hypertension, high cholesterol, body mass index, and smoking playing a major role in its development. The study aims to examine the impact of smoking on heart disease risk, particularly in underweight individuals, and to assess how other factors such as age, sex, diabetes, hypertension, and high cholesterol levels can modify this risk.

Methods:
This study uses a cross-sectional approach and employs Python libraries such as Pandas, Matplotlib, and Scipy to analyze data. The relationship between smoking and heart disease in different Body Mass Index (BMI) groups was investigated using a chi-square test.

Results:
The results of the study suggest that smoking is a major contributor to the risk of heart disease or heart attack, regardless of body mass index (BMI). The findings emphasize the need for individuals to quit smoking in order to reduce their risk of heart disease or attack, particularly for those who are underweight.

Conclusions:
The results have implications for public health and healthcare systems and may require increased efforts to promote healthy lifestyle habits that maintain a normal BMI.

Keywords:
Smoking, Body Mass Index, Heart diseases, Diabetes, Hypertension, High cholesterol.

Background

The cardiovascular system, also known as the circulatory system, is responsible for the transportation of blood, oxygen, and nutrients throughout the body. It is made up of the heart, blood vessels, and blood, and the heart acts as a pump, circulating the blood through the vessels to provide oxygen and nutrients to the body's tissue.[1] Heart disease is a critical global health concern that profoundly impacts individuals and societies. The risk factors asso-

ciated with heart disease include age, sex, diabetes, hypertension, high cholesterol levels, body mass index, and smoking.[2–6] These risk factors are closely linked with the development of heart disease, and it is imperative to understand their interplay to prevent and manage heart disease effectively.

As individuals age, they become more susceptible to developing heart disease.[7] This is due to the gradual accumulation of damage to the cardiovascular system over time. Additionally, aging is associated with changes in lifestyle and the natural progression of biological processes that increase the risk of heart disease. For example, older individuals are more likely to have high blood pressure, high cholesterol levels, and a sedentary lifestyle, which are all risk factors for heart disease.[8,9] Heart disease is the leading cause of death for both men and women globally. However, there are some differences between the sexes in terms of the risk factors and presentation of heart disease. For example, women are more likely to develop heart disease after menopause, when their levels of estrogen decline.[10,11] Diabetes is a chronic disease characterized by high levels of glucose in the blood. People with diabetes are at increased risk of developing heart disease due to the effects of high glucose levels on the cardiovascular system.[3] For example, high glucose levels can damage the blood vessels and increase the risk of clots, which can lead to heart attack and stroke.[12,13] Additionally, people with diabetes are more likely to have other risk factors for heart disease, such as high blood pressure, high cholesterol levels, and obesity.[14] Hypertension, or high blood pressure, is a major risk factor for heart disease. High blood pressure can damage the blood vessels and increase the risk of clots, which can lead to heart attack and stroke.[6] Additionally, high blood pressure can put extra strain on the heart, leading to heart failure and other cardiovascular problems.[8] Excess body weight, particularly abdominal fat, is a significant risk factor for cardiovascular disease as it increases cholesterol and triglycerides levels in the blood, leading to the buildup of plaque in the arteries and decreased blood flow, which raises the risk of heart attack and stroke.[6,15] However, being underweight, defined as having a body mass index (BMI) below 18.5, can also have negative consequences on the cardiovascular system .[16] Smoking is a major contributor to cardiovascular disease, as the chemicals in tobacco smoke harm the inner lining of the arteries, causing them to narrow and stiffen and increasing the risk of blood clots.[5,8]

The study aims to quantify the increased risk of heart disease or heart attack associ-

ated with smoking in different BMI categories with a special interest in the underweight group, as well as determining the role of age, sex, diabetes, hypertension, and high cholesterol level in modifying this risk.

Methods

Source of data

This study is a cross-sectional analysis using data from the 2015 Behavioral Risk Factor Surveillance System (BRFSS) of the Centers for Disease Control and Prevention (CDC) which is an open-access online database and freely accessible to the public under the CC0 1.0 Universal (CC0 1.0) Public Domain Dedication license. The BRFSS is a US-wide annual telephone-based survey system that aims to gather information about behavioral risk factors among adults over.

The initial dataset comprised 330 characteristics and a total of 441,456 records. Cross-sectional information, which included the medical records of a substantial number of individuals classified into underweight, healthy, overweight, and obese groups based on their Body Mass Index (BMI), was utilized. There was no need for ethical approval as the study involved secondary analysis of anonymous data files.

Data Pre-processing

The data preparation process for this study involved various steps to ensure the data was clean and relevant for analysis. The steps included cleaning the data by removing any outliers or missing values, normalizing the data to a specific range, selecting the most important features, and creating new features from existing ones. In the end, the data set consisted of 70692 samples with eight features: age, sex, body mass index (BMI), diabetes, hypertension, high cholesterol levels, smoking, and heart disease or attack. The age feature is divided into 13 categories, with the initial category encompassing individuals aged between 18 and 24. Subsequently, each subsequent category represents individuals ranging from 25 years old to 80 years old, with 5-year increments. The final category includes individuals who are 80 years old or above. All features are categorical variables.

Data Analysis

The study was conducted using Google Colab with the programming language Python and its libraries. The libraries used in this study include Pandas for data manipulation, Matplotlib for data visualization, and Scipy for statistical analysis. A chi-square test was performed on each group based on BMI category to determine the association between smoking and heart disease or attack. The chi-square test of independ-

ence was used to determine if there was a significant relationship between smoking and heart disease or attack for each BMI category. The p-value and the confidence interval were calculated for each group using the chi-square test results. A p-value of less than 0.05 was considered significant, and this information was used to determine if there was a significant difference between smokers and non-smokers for each BMI category.

Results

Table 1: Age Distribution according to BMI groups.

Age	18-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	or 80 more	Above (%) 49
Underweight	31	21	24	28	29	41	58	64	67	88	65	55	82	73
Healthy	443	493	607	700	750	891	1328	1534	1687	1765	1428	1130	1704	73
Overweight	279	460	647	853	1116	1503	2187	2738	3345	3669	2954	2154	2230	80
Obese	226	422	771	1212	1625	2213	3299	4267	5013	5334	3597	2055	1410	79

Table 2: Age distribution according to heart disease or attack.

Heart Disease or Attack	Age Range													Above (%) 49
	18-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	or 80 more	
No	972	1382	2016	2731	3393	4331	6253	7607	8551	8871	6210	4051	3875	75.4
Yes	7	14	33	62	127	317	619	996	1561	1985	1834	1343	1551	95
(%) Yes	0.7	1	1.6	2.3	3.7	7.3	9.9	13.1	18.3	22.4	29.5	33.2	40	

Table 3: Age distribution of the underweight group and other groups in relation to diabetes, hypertension, or High cholesterol levels.

Underweight group														
Age	18-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80 or more	Above 49 (%)
Diabetes	1	0	3	4	5	7	11	14	20	35	17	19	33	88.2
Hypertension	3	2	1	5	7	9	12	19	31	46	26	32	45	88.7
High Cholesterol	96	193	393	756	1211	1915	3382	4735	6050	6835	5051	3266	3045	87.6
Other groups														
Age	18-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80 or more	Above 49 (%)
Diabetes	77	140	311	622	1046	1735	3077	4249	5713	6523	5124	3384	3176	88.8
Hypertension	95	174	348	686	1120	1831	3324	4796	6330	7392	5759	3916	3823	89.3
High Cholesterol	2	3	4	6	6	7	17	19	27	40	32	34	38	88.1

Table 4: Smoking as a risk factor for heart disease or attack in different BMI groups.

BMI Category	No. of Individuals	Sex	Smoker	Individuals with Heart Disease / Attack	Individuals with Heart Disease / Attack (%)	Increase in risk	Increase in risk (%)
Underweight	246	Female	No	14	5.69		
Underweight	204	Female	Yes	46	22.55	4	396
Underweight	58	Male	No	4	6.9		

BMI Category	No. of Individuals	Sex	Smoker	Individuals with Heart Disease / Attack	Individuals with Heart Disease / Attack (%)	Increase in risk	Increase in risk (%)
Underweight	56	Male	Yes	25	44.64	6.5	647
Healthy	5075	Female	No	295	5.8		
Healthy	3251	Female	Yes	384	11.82	2.03	204
Healthy	2361	Male	No	251	10.6		
Healthy	2296	Male	Yes	547	23.88	2.26	225
Overweight	6338	Female	No	637	10.05		
Overweight	4282	Female	Yes	736	17.22	1.71	171
Overweight	5045	Male	No	671	13.21		
Overweight	4984	Male	Yes	1442	28.95	2.19	219
Obese	8449	Female	No	1060	12.51		
Obese	6094	Female	Yes	1275	20.98	1.68	168
Obese	5598	Male	No	992	17.79		
Obese	5906	Male	Yes	2070	34.98	2.25	197

As shown in table 1 The number of each age group of individuals classified as underweight was lower compared to similar age groups of the other categories, with the highest count (88) being recorded in the age group 65-69 and the lowest count (21) being recorded in the age group 25-29 years.

With regards to the "Healthy" category, the number of individuals was generally higher than in the other categories, except in specific age groups where the numbers were similar or lower. In age groups, 18-24, 25-29, and 30-34, the count of individuals in the "Healthy" category was lower than that of individuals in the "Obese" category. However, as the ages increased, the count of individuals in the "Healthy" category increased. It is worth noting that fluctuations were observed in the numbers between age groups.

The number of individuals classified as "Overweight" showed an increase as the ages progressed. Compared to the "Underweight" and "Healthy" categories, the number of individuals classified as "Overweight" was consistently higher, which suggests that a higher proportion of individuals become overweight as they grow older. The "Obese" category had the highest numbers for each age group, indicating a higher prevalence of obesity in the population.

The findings also reveal a progressive increase in the number of individuals with heart disease or heart attack as they age. In the age group of 18-24, only a small fraction of individuals, less than 1%, have a history of heart disease or attack, while 40% of individuals in the age group 80 or more have a recorded history of heart disease or attack, as presented in Table 2. Ad-

ditionally, individuals who are 50 years or older represent a large proportion of those with a history of heart disease or attack, accounting for 95% of the total, while individuals without a history of heart disease or attack in this age group represent 75% of the total. Approximately 73-80% of individuals in each BMI category, as indicated in Table 1, and 88-89% of underweight individuals and other BMI groups, as stated in Tables 3, who suffer from diabetes, hypertension, or high cholesterol, have reached the age of 50 or above.

Table 4 presents the results of the evaluation of the change in the risk of heart disease or attack in different BMI groups among smokers and non-smokers. A comparison of the increased risk between smokers and non-smokers was conducted. The results show that underweight smokers, both female and male, have a significantly higher incidence of heart disease or heart attack compared to their non-smoker counterparts. The increase in risk for female smokers was four times and for male smokers was 6.5 times. The same pattern was observed in individuals with healthy BMI, with smokers having a higher incidence of heart disease or heart attack, resulting in a two-fold increase in risk for both females and males. Similarly, smokers among the overweight and obese groups had a higher incidence of heart disease or heart attack, although the increase in risk was lower compared to individuals with healthy BMI. The results were statistically significant, with a p-value of less than 0.05. The analysis of risk between male and female smokers showed that the average risk for male smokers was higher, but the standard deviation was also higher, suggesting more variability in the risk level among male smokers. The calculated p-value of 0.471 indicated insufficient evidence to reject the null hypothesis, suggesting that the difference in risk between male and female smokers was not statistically significant.

Discussion

Cardiovascular diseases (CVD) are a major global health concern, with obesity being widely recognized as a significant risk factor. The findings suggest that the population is shifting towards being more overweight or obese, particularly as people get older. The highest numbers in each age group belong to the obese category, indicating a higher prevalence of obesity in the population. The increase in overweight and obesity in the population can be attributed to factors such as adverse dietary practices, inactivity, genetics, medical conditions, and socioeconomic status.[8,15,17,18] Further, the results indicate that there is an increase in the number of indi-

viduals with heart disease or heart attack as they age, where the number increases to 40% in the oldest age group of 80 or more. Furthermore, individuals who are 50 years or older represent a large portion of those with a history of heart disease or attack, accounting for 95% of the total. This suggests that the risk of heart disease or heart attack increases with age. These findings are in agreement with the findings of several previous studies.[7,19–21] Moreover, in this study I found that all BMI groups including underweight group specially at 50 years or more have higher incidence of heart disease or attack. However, the role of being underweight in the development of heart diseases remains understudied and largely inconsistent. According to various studies, being underweight is not considered a direct cause of cardiovascular disease (CVD) by most researchers. They attribute the lower incidence of CVD to the absence of CVD-related risk factors, such as hypertension, dyslipidemia, and insulin resistance, among underweight individuals.[20] Large cohort studies that examine risk factors for CVD also do not indicate that being underweight is a risk factor.[19,21–23] The small percentage of underweight people in developed countries can lead to them being grouped with normal-weight individuals in studies, making it challenging to establish the significance of being underweight.[19,24,25] Even when considered as a separate group, the limited number of underweight subjects in previous studies results in wide variability and inconsistent findings.[22,23,26] However, other studies have linked being underweight to increased mortality rates due cardiovascular disease and other causes.[27–29]

Based on this study, it appears that being an underweight smoker is associated with a 6-fold increase in the incidence of heart disease, while being obese is associated with a 2-fold increase in the incidence of heart disease. These findings suggest that both underweight and obesity can increase the risk of heart disease, and that smoking may further amplify this risk for underweight individuals. However, it's important to keep in mind that these results may still be confounded by other factors such as diabetes, hypertension, and high cholesterol levels. However, the fact that both the underweight and obese groups are almost of the same age and have similar rates of diabetes, hypertension, and high cholesterol is an important consideration. This suggests that age and these underlying health conditions are not likely to be confounding the relationship between body weight and heart disease in this study. Therefore, it is possible that smoking is contributing to the higher incidence of heart disease in the underweight group. However, without addi-

tional data and analysis, it is not possible to definitively establish a causal relationship between smoking and heart disease in the underweight group. It would be necessary to control for other possible confounding factors and to assess the strength and significance of the relationship between smoking and heart disease in this group in order to draw a more robust conclusion. For example, there may be other lifestyle factors or underlying health conditions that are contributing to the increased risk of heart disease in both underweight smokers and obese individuals. Therefore, it's important to consider other potential confounders and to control for their influence in the analysis in order to get an accurate estimate of the true relationship between body weight, smoking, and heart disease. To draw a more robust conclusion about the relationship between smoking and heart disease in the underweight group, it would be necessary to conduct a more rigorous study design, such as a prospective cohort study or a randomized controlled trial. In such a study, a sample of underweight individuals could be recruited and followed over time. At baseline, information on various risk factors, including smoking, could be collected. Incidence of heart disease could then be monitored and recorded over a period of time. By controlling for other potential confounding factors and following the same individuals over time, it would be possible to more accurately assess the strength and significance of the relationship between smoking and heart disease in the underweight group. Additionally, it would be important to collect data on a range of other factors that could be contributing to heart disease, such as diet, physical activity levels, alcohol consumption, and stress levels, in order to build a more complete picture of the relationship between smoking and heart disease in this group.

Conclusion

These results provide evidence that smoking is a significant risk factor for heart disease or attack, regardless of BMI. The results highlight the importance of quitting smoking to reduce the risk of heart disease or attack, especially in individuals who are underweight. This may have implications for public health and healthcare systems and may call for increased efforts to promote healthy lifestyle habits to maintain normal body weight.

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