Effect of Sedentary Lifestyle on Cardiovascular Disease Risk Among Healthy Adults With Body Mass Indexes 18.5 to 29.9 kg/m^2

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A substantial proportion of adults at healthy body mass index (BMI) are potentially at high risk for cardiovascular disease (CVD). The objective of this study is to determine if sedentary lifestyle characteristics in healthy weight adults increase their likelihood of being at high CVD risk to that of individuals who are overweight. Adults aged 40 to 79 years in the 2011 to 2016 National Health and Nutrition Examination Survey at a healthy BMI (18.5 to 24.9) and overweight BMI (25 to 29.9; unweighted n = 4,572; weighted n = 43,919,354) were analyzed. The American College of Cardiology/American Heart Association atherosclerotic CVD risk score was used to assess CVD risk. For individuals with a BMI 18.5 to 24.9, 29.6% had increased risk of a CVD event. In logistic regressions adjusted for age, race, gender, education, poverty/income ratio, insurance status, and number of visits to a healthcare provider in the past year, individuals with unhealthy sagittal abdominal diameter (odds ratio [OR] 2.44; 95% confidence interval [CI], 0.97 to 6.14), shortness of breath upon exertion (OR 1.35; 95% CI, 0.65 to 2.79), unhealthy waist circumference (OR 0.99; 95% CI, 0.60 to 1.61), and less than recommended levels of physical activity (OR 0.73; 95% CI, 0.43 to 1.23) were not significantly different than overweight adults in being at high risk for CVD events. Individuals with healthy characteristics and a BMI 18.5 to 24.9 were significantly less likely than overweight adults to be at high risk for CVD. In conclusion, the findings suggest that in individuals at a BMI 18.5 to 24.9, characteristics of a sedentary lifestyle increase the likelihood of being at high risk for CVD to that of overweight individuals. **(Am J Cardiol 2019;123:764−768)**

The most commonly used tool to assist healthcare providers in screening patients for these risk factors is the American College of Cardiology/American Heart Association (AHA)'s Atherosclerotic Cardiovascular Disease (ASCVD) risk score, which has also been endorsed by the US Preventive Services Task Force.[1−4] The ASCVD risk score indicates in asymptomatic adults the probability of having a first CVD event in 10 years based upon several known CVD risk factors such as smoking, blood pressure, diabetes, and lipids. Body composition, particularly body mass index (BMI), is used as a common risk stratification measurement for obesity-related diseases, with "healthy" BMI conveying a low risk.[5] A variety of studies have shown that a substantial proportion of individuals at a BMI from 18.5 to 24.9 have the presence of CVD risk factors like abnormal glucose and hypertension and CVD mortality.[6−9] It is unclear whether patients with a BMI from 18.5 to 24.9 but characteristics of a sedentary lifestyle raise their CVD risk above their counterparts with an active lifestyle to the CVD risk level similar to overweight patients. Thus, the objective of this study is to determine in this nationally representative population-based study of US adults if sedentary lifestyle characteristics in normal weight adults increase their likelihood of being at high CVD risk to that of individuals who are overweight.

Methods

We analyzed data from the National Health and Nutrition Examination Survey (NHANES) for the years 2011 to 2016. The NHANES is a large, nationally representative survey that samples the noninstitutionalized population of the United States using a stratified multistage probability sample design. The application of weights and variables accounting for the complex survey design allows the study to provide nationally representative population estimates for the United States. Consistent with ASCVD risk score guidance, the present study focused on adults aged 40 to 79 years. In adults aged 40 to 79 years, the study focused on those who did not have diagnosed CVD and had a healthy or overweight BMI (unweighted n = 5,016; weighted n = 71,997,650). In addition, participants needed to have complete data to calculate the ASCVD risk score (final unweighted n = 4,572; weighted n = 43,919,354). The 2011 to 2016 NHANES has all the desired variables and is the most currently available data. This study was approved

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as exempt by the University of Florida Institutional Review Board.

Weight and height were measured by a trained examiner in the mobile examination center as part of the NHANES examination and were used to calculate BMI. BMI was calculated as body weight divided by height squared (kg/m^2).[10] BMI values were classified into several conventionally agreed categories upon by the World Health Organization.[11] A healthy BMI was classified as a BMI of 18.5 to 24.9, whereas overweight was classified as 25.0 to 29.9.

The American College of Cardiology/AHA ASCVD risk score uses age, gender, race/ethnicity, smoking status, diabetes status, high-density lipoprotein cholesterol, total cholesterol, systolic blood pressure, and blood pressure medication status to determine the 10-year risk of a first CVD event, such as nonfatal myocardial infarction, coronary heart disease death, and fatal/nonfatal stroke.[3] The 444 respondents (8.8%) who were missing data on any of the ASCVD risk score components were excluded from the analysis, as the ASCVD risk score cannot be computed without complete case data.

Low risk was defined as <7.5% 10-year risk of a CVD event. High risk was defined as ≥7.5% 10-year risk of a CVD event. This follows the guidance provided in the 2013 ACC/AHA guideline on the assessment of cardiovascular risk it recommends that risk assessment should be repeated every 4 to 6 years in persons who are found to be at low 10-year risk (<7.5%). Long-term or lifetime risk estimation is recommended for all persons who are determined to be at low 10-year risk (<7.5%).[12]

Table 1
Characteristics of study sample, NHANES 2011-2016 (unweighted n = 4,572; weighted n = 43,919,354)

40-59 (years)	65.3%
60-79 (years)	34.7%
Men	48.9%
Non-Hispanic White	71.5%
Non-Hispanic Black	8.0%
Hispanic	11.1%
Other	9.4%
Less than high school degree	14.1%
High school graduate or equivalent	19.1%
Some college/degree	66.7%
Poverty to income ratio	
<1.00	12.8%
1.00 or greater	87.2%
Health insurance status	
Private insurance	67.8%
Public insurance	18.5%
No insurance	13.7%
Visits to healthcare provider in last year	
None	14.7%
1	18.3%
2-5	47.2%
>5	19.8%
ASCVD risk	
<7.5% 10-year risk of CVD event	65.4%
≥7.5% 10-year risk of CVD event	34.6%

ASCVD = American Heart Association/American College of Cardiology Atherosclerotic Cardiovascular Disease.

Table 2
Frequency distribution of BMI/lifestyle marker

Sagittal abdominal diameter	
BMI 18.5-24.9, healthy SAD	35.8%
BMI 18.5-24.9, unhealthy SAD	4.7%
BMI 25.0-29.9	59.4%
Shortness of breath	
BMI 18.5-24.9, no shortness of breath	33.1%
BMI 18.5-24.9, has shortness of breath	7.6%
BMI 25.0-29.9	59.3%
Activity	
BMI 18.5-24.9, active	25.4%
BMI 18.5-24.9, inactive	15.3%
BMI 25.0-29.9	59.3%
Sitting time	
BMI 18.5-24.9, not excess sitting time	25.4%
BMI 18.5-24.9, high levels of sitting time	15.3%
BMI 25.0-29.9	59.3%
Waist circumference	
BMI 18.5-24.9, healthy waist circumference	20.4%
BMI 18.5-24.9, unhealthy waist circumference	20.4%
BMI 25.0-29.9	59.2%

BMI = body mass index; SAD = sagittal abdominal diameter.

Sagittal abdominal diameter (SAD) is a simple anthropometric index of visceral adiposity and has been correlated with obesity-related metabolic disturbances and risk scores. SAD was measured 3 times using standardized methods.[13] Although still widely debated, SAD is said to be a better predictor of cardiovascular disease than BMI, waist circumference (WC), and waist-hip ratio.[14,15] An unhealthy SAD was defined as an SAD of >22 cm for men and >20 cm for women.[16] SAD was missing for 145 participants (3.2%).

WC measured a horizontal line just above the uppermost lateral border of the right ilium for participants at standing position using measuring tape.[13] An unhealthy WC was defined as a WC of >102 cm for men and >88 cm for women.[17,18] Data were missing for 107 participants (2.3%).

Table 3
Differences in ASCVD risk between normal weight unhealthy marker, normal weight healthy marker, and overweight, NHANES 2011 to 2016 (unweighted n = 4,572; weighted n = 43,919,354)

	Risk ≥ 7.5%	p Value
BMI 18.5-24.9, healthy SAD	26.2%	<0.0001
BMI 18.5-24.9, unhealthy SAD	51.4%	
BMI 25.0-29.9	37.8%	
BMI 18.5-24.9, normal breath	26.7%	<0.0001
BMI 18.5-24.9, shortness of breath	42.1%	
BMI 25.0-29.9	38.0%	
BMI 18.5-24.9, active	27.0%	<0.0001
BMI 18.5-24.9, inactive	33.7%	
BMI 25.0-29.9	37.9%	
BMI 18.5-24.9, not excessive sitting	31.1%	p = 0.0007
BMI 18.5-24.9, high levels of sitting	27.1%	
BMI 25.0-29.9	38.0%	
BMI 18.5-24.9, healthy waist circumference	29.9%	p <0.0001
BMI 18.5-24.9, unhealthy waist circumference	28.3%	
BMI 25.0-29.9	37.9%	

BMI = body mass index; SAD = sagittal abdominal diameter.

Table 4
Unadjusted and adjusted odds ratios from logistic regression analysis using the NHANES 2011 to 2016 (unweighted n = 4,572; weighted n = 43,919,354)

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*
BMI 18.5-24.9, healthy SAD	0.59 (0.48-0.71)	0.56 (0.39-0.79)
BMI 18.5-24.9, unhealthy SAD	1.74 (1.18-2.58)	2.44 (0.97-6.14)
BMI 25.0-29.9	1.00	1.00
BMI 18.5-24.9, normal breath	0.59 (0.49-0.72)	0.55 (0.40-0.77)
BMI 18.5-24.9, shortness of breath	1.19 (0.83-1.71)	1.35 (0.65-2.79)
BMI 25.0-29.9	1.00	1.00
BMI 18.5-24.9, active	0.61 (0.49-0.76)	0.66 (0.44-0.99)
BMI 18.5-24.9, inactive	0.83 (0.64-1.08)	0.73 (0.43-1.23)
BMI 25.0-29.9	1.00	1.00
BMI 18.5-24.9, not excessive sitting	0.74 (0.60-0.91)	0.78 (0.49-1.23)
BMI 18.5-24.9, excessive sitting	0.61 (0.46-0.81)	0.54 (0.35-0.82)
BMI 25.0-29.9	1.00	1.00
BMI 18.5-24.9, healthy waist circumference	0.70 (0.54-0.90)	0.48 (0.32-0.73)
BMI 18.5-24.9, unhealthy waist circumference	0.65 (0.54-0.78)	0.99 (0.60-1.61)
BMI 25.0-29.9	1.00	1.00

BMI = body mass index; SAD = sagittal abdominal diameter.

* Logistic regression models were adjusted for age, race, gender, education, poverty/income ratio, insurance status, and number of visits to a healthcare provider in the past year.

The respondents were asked whether they ever experienced shortness of breath either when hurrying on the level or walking up a slight hill. Although affirmative answers are not completely discriminatory of a sedentary lifestyle, this general indication of fitness would be consistent with either an active or sedentary lifestyle. Data were missing for 6 participants (0.13%).

Moderate/vigorous physical activity was defined using measurements of average minutes per day of moderate and vigorous work and recreational activities that occurred for at least 10 minutes. A binary variable was created that indicated whether the respondent met the American College of Sports Medicine's exercise guideline of ≥150 minutes of moderate weekly exercise or ≥75 minutes of vigorous exercise.[19,20] Data were missing for 15 participants (0.33%).

Prolonged sitting time represents a risk factor for mortality and CVD as a sedentary lifestyle.[21] Respondents were asked a question about how many minutes they spent sitting at school, at home, getting to and from places, or with friends on a typical day. A recent study found increased risk of heart disease at 7.7 hours (>462 minutes) of sitting per day or more.[22] This cut point was used to identify high levels of sitting time. Data were missing for 29 participants (0.63%).

All demographic items were self-reported and include age, gender, race/ethnicity, education, poverty-to-income ratio (PIR), health insurance status, and healthcare utilization. For multivariate modeling, age is categorized as 40 to 59 and 60 to 79. The ASCVD risk score calculates risk differently according to race, but only considers White and Black. For the purposes of the risk score calculation, race was categorized as White (including Hispanic and other) and non-Hispanic Black. For multivariable analysis in regression models, race was categorized as non-Hispanic White, non-Hispanic Black, Hispanic, and other. Education was categorized as less than high school (<12 years of education), high school (12 years of education), and some college/degree (>12 years of education). PIR was categorized as <1.0 (family income is less than the official definition of poverty) and ≥1.0 (family income is above the poverty level). Health insurance status was categorized as private, public, and none. Healthcare utilization was defined by a question asking about the number of visits to a provider in the past year.

The NHANES uses a stratified multistage probability design. To account for the complex sample design of the NHANES, SAS 9.4 (SAS Institute, Cary, North Carolina) and SUDAAN 11.0.1 (RTI International, Research Triangle Park, North Carolina) were used with the appropriate design and weighting variables provided by the National Center for Health Statistics. The National Center for Health Statistics suggests that estimates are considered to be reliable if the standard error is less than 30% of the population parameter estimate.

We calculated chi-square analysis to determine the difference in normal weight adults between those individuals with <7.5% 10-year risk of a CVD event, ≥7.5% 10-year risk and overweight adults and the independent variables consistent with a sedentary lifestyle. Chi-square analysis utilized pairwise deletion for cases of missing data. Forced inclusion logistic regressions controlling for age, gender, race, education, PIR, insurance status, and number of visits to a healthcare provider in the past year were conducted to assess the impact of sedentary lifestyle markers on the likelihood of being at high CVD risk. Multivariable models utilized listwise deletion in the event of missing data.

Gender- and race-specific subanalyses were not conducted as gender and race are both accounted for in the ASCVD risk score.

A subgroup analysis was conducted to assess whether excess sitting time was moderated by high levels of activity. Adjusted and unadjusted forced inclusion logistic regression models were conducted, controlling for age, gender, race, education, PIR, insurance status, and number of visits to a healthcare provider in the past year.

Results

Table 1 shows the demographic characteristics of the study sample. Overall, a substantial percentage of the sample had increased risk of a CVD event. Table 2 shows the frequency distribution of the combination of BMI and lifestyle marker. Table 3 shows the chi-square test results for the assessment of BMI and lifestyle marker, and how healthy BMI individuals with unhealthy markers compare with their normal weight and overweight peers. For most combinations of lifestyle markers and BMI, results showed that risk for the 3 groups was significantly different for every health marker assessed. The healthy BMI/unhealthy marker group tended to be at high risk for a CVD event between overweight and their healthier peers. Table 4 shows the logistic regression analysis. Adjusted models indicate that for SAD, shortness of breath, activity level, and WC, there is not a significant difference between those who have a healthy BMI and unhealthy markers and those who are overweight. However, individuals with a healthy BMI and healthy markers are at lower likelihood of being high risk for CVD than individuals who are overweight. The only variable where the individuals at a healthy BMI with a sedentary lifestyle marker were different from overweight individuals was extended sitting.

A subgroup analysis was conducted in individuals with extended sitting to determine if this effect was modified by vigorous exercise. In unadjusted analyses, individuals with a healthy BMI, excessive sitting, and meeting the American College of Sports Medicine guidelines for exercise exhibited findings like the other nonsedentary characteristics and these individuals were less likely than overweight adults to be at high risk for CVD (odds ratio [OR] = 0.51; 95% confidence interval [CI] = 0.36 to 0.72). Also, similar to the other sedentary characteristics, individuals with a healthy BMI, excessive sitting, and not active in terms of exercise, these individuals were not significantly different from overweight adults to be at high risk for CVD (OR = 0.73; 95% CI = 0.49 to 1.01). Adjusted analyses yielded similar relationships with individuals with extended sitting and high levels of exercise being less likely than overweight adults to be at high risk for CVD (OR = 0.42; 95% CI = 0.24 to 0.72) and individuals with extended sitting and low levels of exercise being not significantly different from overweight adults to be at high risk for CVD (OR = 0.68 [95% CI = 0.34 to 1.37]).

Discussion

The findings of this study provide new insights into the relation between BMI, body composition, characteristics associated with a sedentary lifestyle, and high risk for CVD. It suggests that not all individuals at a healthy BMI, individuals who are typically considered as being healthy, are at low CVD risk. Characteristics of a sedentary lifestyle, exemplified by exercise or body composition are distinguishing variables. These findings suggest that a common thinking for CVD prevention strategy primarily based on BMI and weight loss to a healthy BMI to ensure decreased risk may be need to be amended.

Additionally, characteristics of being "unfit" (i.e., shortness of breath and being inactive) in individuals with a healthy BMI increased their likelihood of being at high-risk for CVD to a level that was not different from individuals who were overweight. The present study indicated a counterintuitive finding related to extended sitting time and CVD risk in adults with healthy BMIs. Those sedentary lifestyle indicators may play better roles in predicting CVD risk. A recent study found that individuals who are not consistently sedentary with physical activity tend to have lower CVD mortality.[23] Moreover, physical activity is independently associated with reduced CVD risk regardless of amount of sedentary activity time.[24] Our subgroup analysis reinforced this idea and indicated that the relation between excessive sitting time and CVD risk in adults with healthy BMIs can be modified by other indicators of physical activity. Individuals who had excessive sitting but reported getting sufficient exercise were significantly less likely to have a lower CVD risk than those who reported excessive sitting without sufficient exercise and overweight adults. It may be more informative that moderate/vigorous activity and having normal reported fitness are markers that are indicative of adequate fitness rather than whether the individual reports substantial sitting. Rather than measuring sitting time, a measurement of prolonged sedentary time without physical activity may play a critical role in incrementing CVD risk.

Unhealthy levels of SAD and WC in adults at a healthy BMI were associated with an increased likelihood of being at risk for CVD similar to adults who were overweight. The existing evidence that SAD as a practical proxy of visceral fat was useful in discriminating CVD risk in individuals at a healthy BMI. It highlights the importance of additional body composition assessment in discriminating the healthy BMI population who are typically neglected in CVD prevention.[25] The findings also support other research that suggests that individuals at a healthy BMI with body composition indicators like decreased grip strength or high percentage of body fat are associated with hypertension and abnormal glucose.[8,26] Thus, it may be useful to integrate other measurements of body composition into the clinician's risk stratification model for adult patients with healthy BMIs.

There are several limitations that need to be considered when interpreting these results. First, although we used the currently accepted and endorsed risk score for atherosclerotic CVD, the ASCVD risk score, some authors have voiced concern as to whether the pooled equations overestimate CVD risk in some groups.[27,28] Moreover, there may be some concern that the a 10-year risk of CVD at 7.5% which was recommended in the guideline may be seen as an arbitrary cut point. Second, fitness was measured by self-report of getting out of breath upon mild exertion. It is possible that this general measurement is too nonspecific for fitness, but self-reports of fitness are associated with objective measurements of cardiorespiratory fitness.[29,30]

The study results are generalizable to the adult US population, aged 40 to 79, who are free of CVD and are of a healthy or overweight BMI as the study utilized data designed to be nationally representative. In conclusion, this study provides additional evidence that fitness and body composition markers consistent with a sedentary lifestyle distinguish individuals with healthy BMIs as likely to be at increased risk for cardiometabolic outcomes. Encouraging patients to maintain or achieve a healthy BMI may not be enough to ensure lower CVD risk and CVD prevention.

Messaging about a healthy lifestyle may benefit from additional focus on achieving sufficient physical activity.

Disclosures

The investigators have no conflicts of interest to disclose.

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