Introduction:

Cardiovascular disease is the leading cause of death globally, responsible for an estimated 19.8 million deaths in 2022 which is a significant proportion of total global mortality (32%). These afflictions include any disorder of the heart and blood vessels, including coronary heart disease, cerebrovascular disease, peripheral arterial disease, and many more (*Cardiovascular Diseases (CVDs)*, n.d). These conditions can be precipitated and exacerbated by various risk factors, some of which are high blood pressure or high cholesterol. Cardiovascular disease is also influenced by behavioral factors, including smoking, alcohol consumption, and physical activity level (CDC, 2024a).

The National Health and Nutrition Examination Survey (NHANES) collects statistics about behavioral and health characteristics of participants of all ages in the United States. It is unique in that it is the only comprehensive dataset that collects and compiles detailed data about social and health characteristics from a broad population of all ages (CDC, 2024b). This allows for the detailed analysis of population level health patterns and their potential determinants.

Research Questions and Hypotheses:

This analysis examines data from the 2021-2023 NHANES dataset to investigate three research questions:

1. What is the relationship between dietary fiber intake and total cholesterol levels?
    a. H_1: Increased dietary fiber intake will correlate to lower cholesterol levels
    b. H_0: There is no significant relationship between dietary fiber intake and cholesterol levels
2. How does physical activity level relate to systolic blood pressure across different age groups?
    a. H_1: Increased physical activity will correlate to a lower systolic blood pressure, and this association will be stronger in older age groups
    b. H_0: There is no significant correlation between physical activity and systolic blood pressure across different age groups
3. Do these relationships differ by gender?
    a. H_1: Females will show a stronger association between dietary fiber intake and cholesterol levels and men will show a stronger association between physical exercise and mean systolic blood pressure
    b. H_0: There are no differences in these relationships between males and females

These hypotheses were developed based on existing literature that attributes increased physical activity to lower blood pressure and increased dietary fiber to decreased cholesterol (MD, 2023). Furthermore, there is a physiological basis for the gender related hypotheses (de Oliveira Carpes et al., 2021) (Mumford et al., 2011). This could potentially aid in making informed recommendations to public health officials regarding guidance on physical activity and dietary patterns in order to prevent cardiovascular disease.

Methods:

I analyzed data from the 2021-2023 NHANES dataset (*August 2021-August 2023 Dietary Data - Continuous NHANES*, n.d.). which was collected through household interviews, standardized physical examinations, and laboratory analyses of biological samples. I included five data components in my analysis: demographics (DEMO_L), blood pressure examination (BPXO_L), total cholesterol laboratory results (TCHOL_L), physical activity questionnaire

(PAQ_L), and dietary interview data (DR1TOT_L). These datasets were merged using the unique participant sequence number (SEQN) and subsequently the analysis was restricted to adults aged 20 years and older with complete data on all variables of interest. This led to a final sample size of 4,234 participants (2358 females and 1876 males).

Variables:
Systolic blood pressure: the main outcome was systolic blood pressure which was measured in mmHg using an oscillometer. The first systolic reading was used from the dataset.
Physical Activity: Physical activity was categorized into three groups based on responses to the Physical Activity Questionnaire. Participants were classified as "Active: if they reported intense recreational activities (PAQ650 = 1), "Moderate" if they reported moderately intense recreational activities (PAQ665 = 1), and "Sedentary" if they reported neither intense nor moderate recreational activities.
Dietary Fiber Intake: Daily dietary fiber intake was recorded in grams and obtained from the 24-hour dietary recall interview, representing total fiber consumption on the day before the interview.

Statistical Analysis
The relationship between physical activity and systolic blood pressure was examined using analysis of variance (ANOVA) and subsequently stratified by age group which is shown in Figure 2. The association between dietary fiber intake and total cholesterol was examined using Pearson correlation coefficients and linear regression. Furthermore gender-stratified analyses were conducted to examine potential effect modification. Statistically significant results were those with a p-value less than $\alpha = 0.05$.

Results:
Sample Characteristics:
The sample included 4,234 adults with ages ranging from 20-80 years (mean: 48.6). The sample included 2,358 females (55.7%) and 1,876 males (44.3%). Physical activity distribution showed that 892 participants were classified as active (21.1%), 2,057 participants were classified as moderately active (48.6%), and 1,285 were classified as sedentary (30.4%).

Dietary Fiber and Cholesterol:
The correlation between dietary fiber intake and cholesterol was insignificant ($r = 0.010$, $p = 0.50$). Similarly linear regression analysis which is shown in Figure 1 showed no meaningful relationship, with a slope of 0.05 mg/dL per gram of fiber ($R^2 < 0.001$, $p = 0.50$). When stratified by gender, the analysis elicited similar results, showing weak correlation in both males ($r = 0.014$) and females ($r = 0.052$). These findings show that there is no clinically significant relationship between fiber intake and cholesterol amongst either males or females.

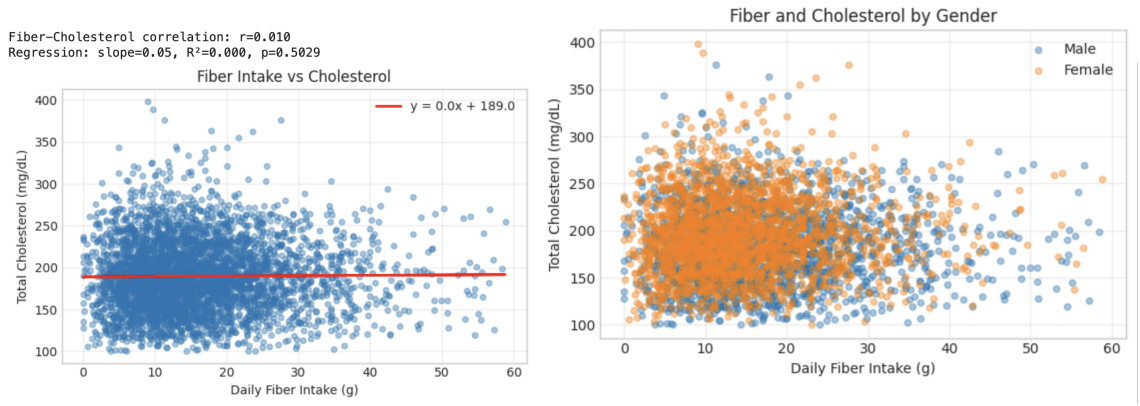

Figure 1: Regression curve showing the relationship between Daily Fiber Intake (g) and Total Cholesterol (mg/dL). Total sample result shown on left and gender stratified result on the right.

Physical Activity and Blood Pressure:

The mean systolic blood pressure amongst the different age groups and physical activity levels can be seen in Table 1 and is visualized in Figure 3 below:

Age Group (years of age)	Activity Level	Mean Systolic Blood Pressure (mmHg)
20-39	Active	114.885167
	Moderate	113.087234
	Sedentary	113.006061
40-59	Active	120.841912
	Moderate	121.567839
	Sedentary	121.816000
60+	Active	129.708642
	Moderate	128.092308
	Sedentary	128.868056

Table 1: Mean Systolic Blood Pressure Amongst Varied Physical Activity and Age

ANOVA: F=0.61, p=0.5437

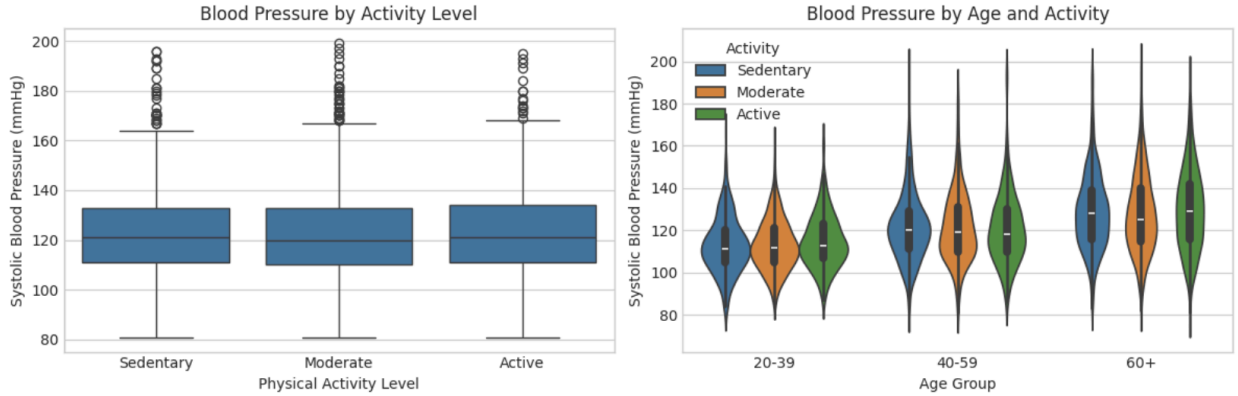

Figure 2: ANOVA test showing the correlation between activity level and systolic blood pressure (mmHg). Total sample results on the left and results stratified by age on the right.

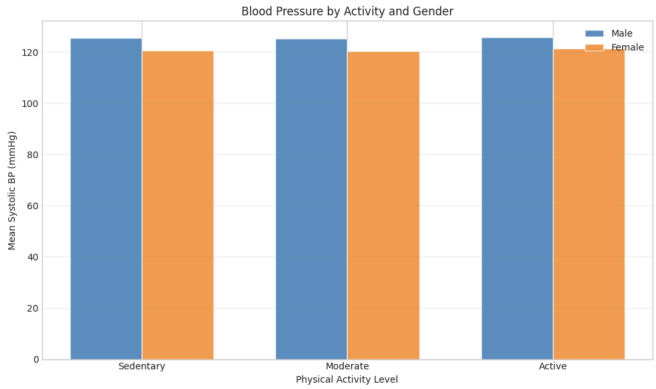

Figure 3: Mean systolic blood pressure stratified by physical activity and gender

Discussion:

The results found from this analysis do not match my predicted hypotheses. The p-value for the relationship between dietary fiber intake and cholesterol amongst the whole sample was found to be 0.5, which is greater than the set $\alpha = 0.05$ indicating that there is no statistically significant relationship between dietary fiber intake and cholesterol. Furthermore, I would have expected a negative slope from the regression line analysis indicating that higher dietary fiber intake is associated with lower cholesterol. However, the slope was 0.05 which is positive and near zero, showing that there is no significant association between the two variables. This deviance from the predicted results could be due to the methodology utilized in NHANES data collection. The dietary fiber intake was collected over the course of 24 hours, which may not accurately reflect the true eating habits of participants. Furthermore, the relationship between fiber intake and total cholesterol was analyzed, however fiber primarily affects LDL cholesterol and it is predicted that 5-10 grams of soluble fiber per day can noticeably reduce LDL cholesterol (*Can Eating Certain Foods Help Improve Your Cholesterol Levels?*, n.d.). Interestingly the correlation in females (r = 0.052) was slightly higher than men (r = 0.014) which aligns with my hypothesis but both are still near zero so conclusions cannot be drawn from these results. Additionally there was not a significant difference in mean blood pressure amongst different genders.

Similarly the results regarding the relationship between physical activity and mean blood pressure was insignificant, with an F-value of 0.61 and a p-value of 0.5437. An F-value lower than 1 indicates that the variation seen is likely due to chance, and this is corroborated by a p-value much higher than 0.05. This could be because the analysis was based on self reported data, and did not necessarily account for total daily movement or other occupational movement. Furthermore, the data was based on a single point in time rather which may not accurately reflect sustained activity patterns.

Limitations and Future Directions:

There are several limitations associated with this study. First, due to the cross-sectional nature of the NHANES dataset (the data was collected at a single point in time) the relationships between the different variables cannot be deduced. Secondly, the analysis did not account for potential confounders such as BMI, smoking status, alcohol consumption, socioeconomic factors, medication use, or comorbidities which are all factors that may influence cardiac health. Third, there could have been significant biases in the self reported data due to societal pressures in reporting healthy behaviors. Finally, the NHANES is an extremely complex survey and the analysis did not account for this. The data was treated as a simple random sample rather than applying appropriate sampling weights. Future research can address these limitations. Specifically researchers can analyze longitudinal studies that follow individuals for longer periods of time. Including objective measures of activity such as accelerometry could also mitigate any potential recall biases. Adjustments for confounders would also be critical for an accurate analysis, and finally the study should account for the survey design itself and use sampling weights.

Conclusion:

The results from analysis aligned with the null hypotheses for all the research questions, and there was no significant relationships found between physical activity and mean blood pressure or dietary fiber intake and cholesterol levels. These findings likely reflect methodological limitations rather than an absence of the relationships as they are already well established in the literature. These results highlight the need for appropriate study design and confounder adjustment, as well as the importance of longitudinal data for lifestyle choices.

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