Sleep Trouble and BMI in Adults Over 30: Testing the Moderating Role of Physical Activity

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Introduction

Background

Sleep quality plays a critical role in metabolic health and has been linked to weight regulation through hormones such as leptin and ghrelin. Individuals with insufficient or disrupted sleep often exhibit metabolic dysregulation, including impaired appetite control and increased risk of obesity. In parallel, regular physical activity is well-established as a protective factor, improving metabolic efficiency and lowering overall obesity risk.

Literature Summary

A substantial body of research has shown that poor sleep is associated with higher body mass index (BMI), and that physical activity tends to reduce BMI through improved energy balance and insulin sensitivity. However, most of these studies have treated sleep and activity as independent predictors rather than examining potential interactions.

Research Gap

Despite these connections, relatively few studies have tested whether physical activity moderates the association between sleep quality and BMI, particularly in mid- and later-life adult populations. Given the increasing burden of sleep disorders and obesity in aging adults, understanding these relationships is essential.

Study Hypothesis

We hypothesize that, among adults over age 30, those who report sleep trouble will have higher BMI. Furthermore, we hypothesize that physical activity will moderate this association, such that the relationship between sleep trouble and BMI is attenuated among physically active individuals.

Methods

Data Source

The data used in this study came from the National Health and Nutrition Examination Survey (NHANES), a publicly available, nationally representative dataset collected by the Centers for Disease Control and Prevention (CDC). NHANES is designed to assess the health and nutritional status of adults and children in the United States through a combination of interviews, physical examinations, and laboratory tests. For this project, we used the consolidated NHANES dataset provided by the course, which includes key demographic and health variables necessary for our analysis. All data used in this study are de-identified and publicly available.

Study Sample

Participants were included in the analysis if they were over the age of 30 and had complete data for sleep trouble status, body mass index (BMI), and physical activity. We excluded individuals with missing values for any of these variables. Additionally, we restricted the analytic sample to participants with biologically plausible BMI values between 15 and 60 kg/m^2 to eliminate extreme or likely erroneous values. After applying these criteria, the final analytic sample consisted of 3,622 adults.

Variable Definitions

The primary outcome in this study was self-reported sleep trouble, categorized as a binary variable: “Yes” responses were coded as 1 and “No” responses as 0. The main predictor was body mass index (BMI), calculated as weight in kilograms divided by height in meters squared. To improve the interpretability of model coefficients, BMI was also scaled as a continuous variable in 5-unit increments (BMI_5unit = BMI / 5), allowing odds ratios to reflect more clinically meaningful differences in weight. Physical activity status was based on self-report and dichotomized as “Yes” or “No” to indicate regular participation in physical activity. BMI was also categorized using World Health Organization (WHO) cutpoints into four levels: Underweight (<18.5), Normal (18.5–24.9), Overweight (25.0–29.9), and Obese (≥30).

Statistical Analysis

We began by summarizing demographic and health characteristics across participants with and without reported sleep trouble. Continuous variables (age and BMI) were summarized using means, standard deviations, medians, standard errors, and 95% confidence intervals (Table 1A), while categorical variables (sex, physical activity, and BMI category) were summarized with frequencies and percentages (Table 1B). Between-group differences were assessed using two-sided t-tests for continuous variables and Pearson's chi-square tests for categorical comparisons.

To formally evaluate the association between BMI and sleep trouble, we constructed a sequence of logistic regression models. Model M0 was an intercept-only baseline model. Model M1 added BMI_5unit as a continuous predictor. Model M2 added physical activity status as a main effect. Model M3 included an interaction term between BMI_5unit and physical activity to test for moderation. For each model, we reported odds ratios (ORs), 95% confidence intervals (CIs), p-values, and Akaike Information Criterion (AIC) values. Nested models were compared using likelihood ratio tests. Predicted probabilities from Model M3 were plotted by BMI and physical activity status (Figure 3). All analyses were conducted in RStudio using dplyr, ggplot2, and stats packages.

A participant flow diagram is presented in Figure 1 to illustrate how the final analytic sample was derived. Starting from the raw NHANES dataset (N = 6,779), we removed duplicate entries, excluded participants under age 30, and filtered out cases with missing data for sleep trouble, BMI, or physical activity. We then restricted the sample to those with biologically plausible BMI values between 15 and 60 kg/m². These steps yielded a final analytic cohort of 3,622 adults.

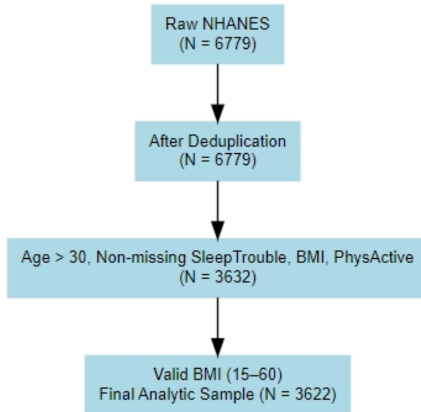

Figure 1 Flow diagram showing participant inclusion from raw NHANES data to final analytic sample (N = 3,622)

After preparing the final analytic dataset, we followed a structured modeling sequence to evaluate both main effects and potential moderation. As shown in Figure S1, we began with exploratory tests, then constructed a series of nested logistic regression models to test our primary and secondary hypotheses. This stepwise approach allowed us to isolate the effect of BMI, assess the independent role of physical activity, and evaluate whether physical activity modified the relationship between BMI and sleep trouble.

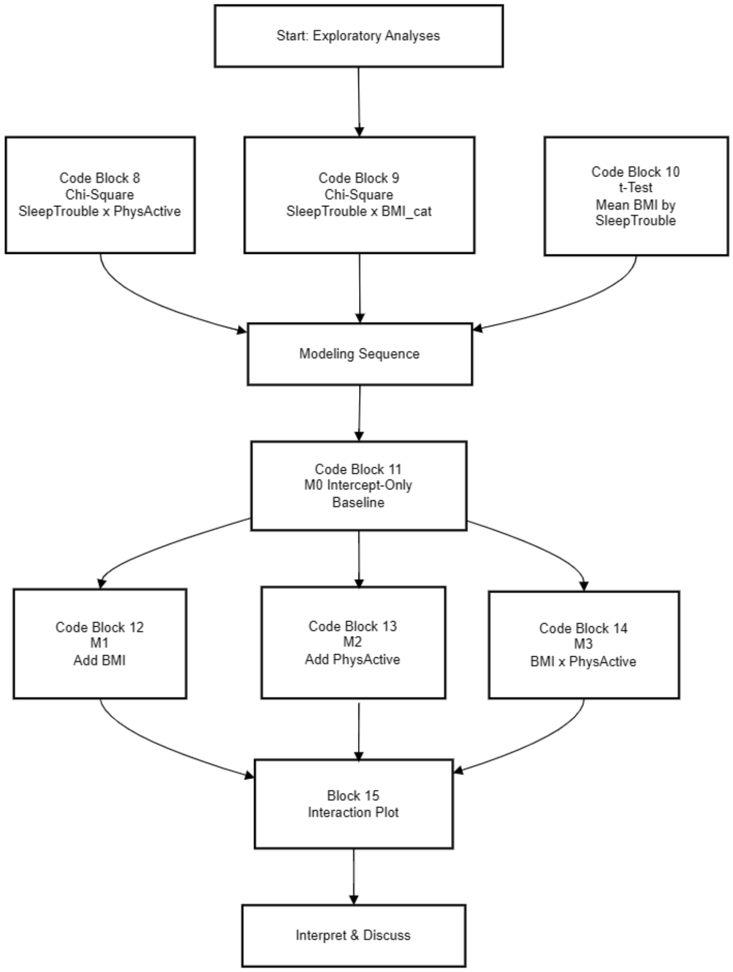

Figure S1 Modeling workflow summarizing the sequence of statistical tests and nested logistic regression models (M0–M3) used to evaluate the association between BMI, physical activity, and sleep trouble

Results

Descriptive Statistics

Among 3,622 adults over age 30 included in the final analytic sample, 994 participants (27.4%) reported having trouble sleeping (Figure 2). Table 1A summarizes age and BMI across SleepTrouble groups. On average, participants with sleep trouble were slightly older (M = 54.6 years, SD = 13.9) compared to those without sleep trouble (M = 52.9 years, SD = 14.8). They also had a higher BMI (M = 30.0, SD = 7.1) versus participants without sleep trouble (M = 28.8, SD = 6.1).

Table 1B provides categorical breakdowns. Obesity was more prevalent among participants reporting sleep trouble (41.8%) compared to those without (35.4%). Physical activity status was relatively balanced between groups, with 53.6% of the sleep trouble group reporting “No” to being physically active versus 51.8% in the group without sleep trouble. Figure 3 further illustrates the BMI distribution by group, showing a higher median BMI and wider upper range among those with sleep trouble.

1.1. Table 1A

Table 1A. Continuous Descriptives by Sleep Trouble

Variable	Mean_No	SD_No	Mean_Yes	SD_Yes
Age	52.9	14.8	54.6	13.9
BMI	28.8	6.1	30.0	7.1

Table 1A. Mean, SD, and 95% confidence intervals for age and BMI by SleepTrouble status

1.1. Table 1B

Table 1B. Categorical Descriptives by Sleep Trouble

Variable	Count_No	Count_Yes	Percent_No	Percent_Yes
Sex: Female	1,295	578	49.3	58.1
Sex: Male	1,333	416	50.7	41.9
PhysActive: Yes	1,268	461	48.2	46.4
PhysActive: No	1,360	533	51.8	53.6
BMI: Underweight	32	10	1.2	1.0
BMI: Normal	705	233	26.8	23.4
BMI: Overweight	962	336	36.6	33.8
BMI: Obese	929	415	35.4	41.8

Table 1B. Frequencies and column percentages for sex, physical activity, and BMI category by SleepTrouble status

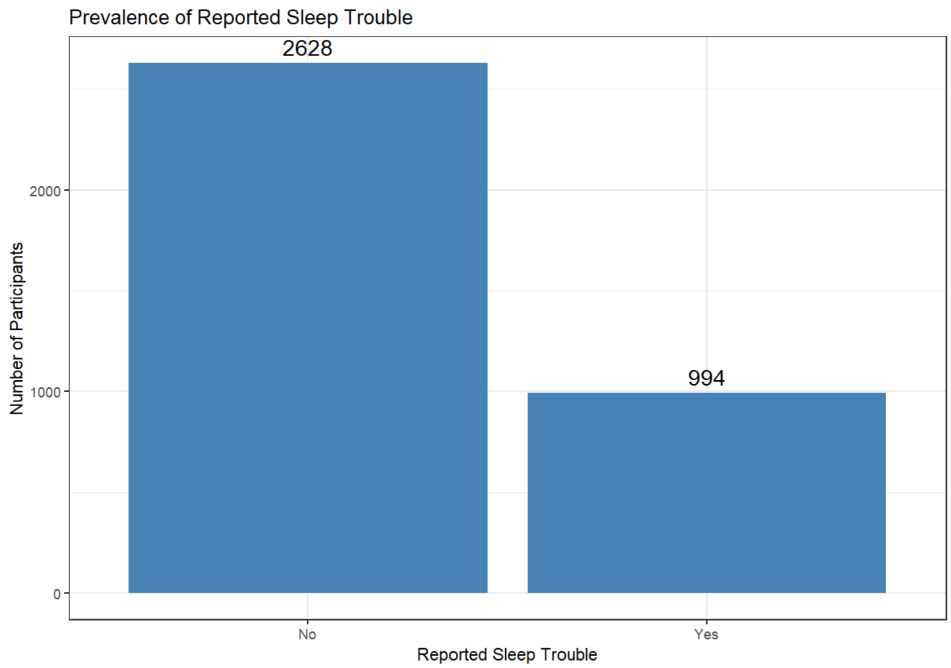

Figure 2 Bar plot showing the proportion of participants who reported having trouble sleeping (Yes = 27.4%, No = 72.6%)

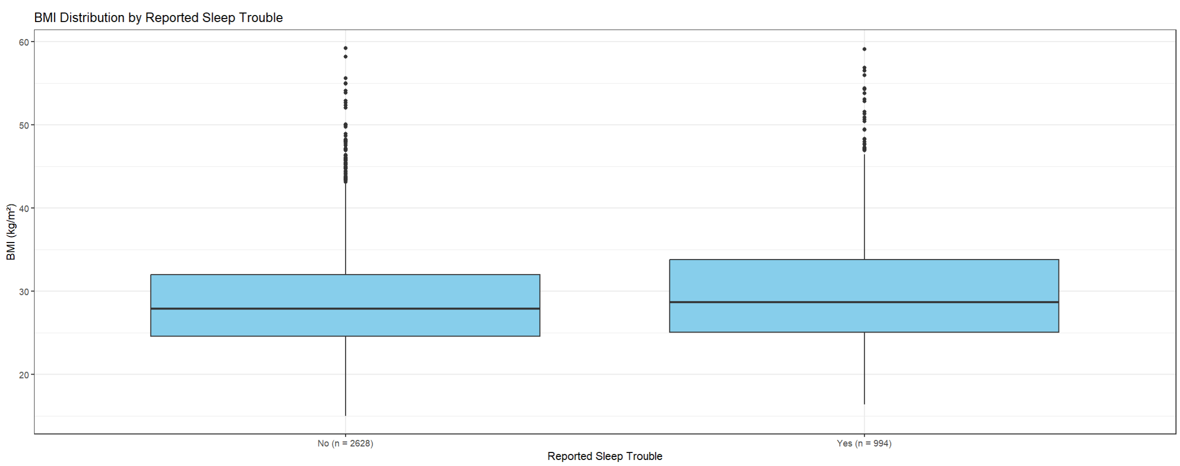

Figure 3 Boxplot comparing BMI distribution between participants with and without reported sleep trouble. The sleep trouble group shows a higher median BMI and greater variability

Exploratory Analyses (t-test + chi-squares)

We conducted an independent samples t-test to compare mean BMI between participants with and without reported sleep trouble. The results indicated a significant difference between groups ($t = -4.63$, $df = 1580.5$, $p < 0.001$), with those reporting sleep trouble having a higher average BMI ($M = 29.97$, $SD = 7.1$) compared to those without ($M = 28.80$, $SD = 6.1$).

A chi-square test of independence was used to examine the relationship between physical activity status and sleep trouble ($\chi^2 = 0.94$, $p = 0.33$). The test did not reveal a statistically significant association, indicating that physical activity alone was not associated with reporting sleep trouble.

In contrast, a significant association was found between BMI category and sleep trouble status ($\chi^2 = 13.01$, $df = 3$, $p = 0.0046$). Participants categorized as obese were disproportionately more likely to report sleep trouble (41.8%) compared to those in the normal (23.4%) or overweight (33.8%) BMI groups.

Logistic Modeling Results (M0–M3)

Table S1 summarizes the results from four nested logistic regression models predicting the odds of reporting sleep trouble. Model M0 included only the intercept and estimated baseline prevalence. Model M1 added BMI_5unit as a continuous predictor and showed a significant association: each 5-unit increase in BMI was associated with a 15% increase in odds of sleep trouble (OR = 1.15, 95% CI: 1.09–1.22, $p < 0.001$), with an AIC improvement from 4258.7 (M0) to 4236.9 (M1).

Model M2 added physical activity status as an additional predictor. The effect of BMI remained significant, but physical activity was not independently associated with sleep trouble (OR = 0.97, 95% CI: 0.84–1.13, $p = 0.73$), and the model did not significantly improve (AIC = 4238.8; LRT $p = 0.73$).

In Model M3, we tested the interaction between BMI_5unit and physical activity. The interaction term was not significant (OR = 0.98, 95% CI: 0.87–1.10, $p = 0.70$), and model fit did not improve over M2 (AIC = 4240.6). Figure 4 visualizes the predicted probability of sleep trouble across BMI levels for physically active and inactive individuals, showing parallel slopes and overlapping confidence intervals—further supporting the lack of moderation.

Table S1: Logistic Regression Model Comparison

Model	Predictors	OR (BMI)	OR (PhysActive)	OR (Interaction)	AIC	LRT p
M0	Intercept only				4,258.7	
M1	+ BMI_5unit	1.15 (1.09–1.22)			4,236.9	< 0.001
M2	+ BMI_5unit + PhysActive	1.15 (1.08–1.22)	0.97 (0.84–1.13)		4,238.8	0.73
M3	+ BMI_5unit + PhysActive + Interaction	1.15 (1.08–1.22)	0.97 (0.84–1.13)	0.98 (0.87–1.10)	4,240.6	0.70
Note: OR = odds ratio; LRT = likelihood ratio test. CI = 95% confidence interval.						

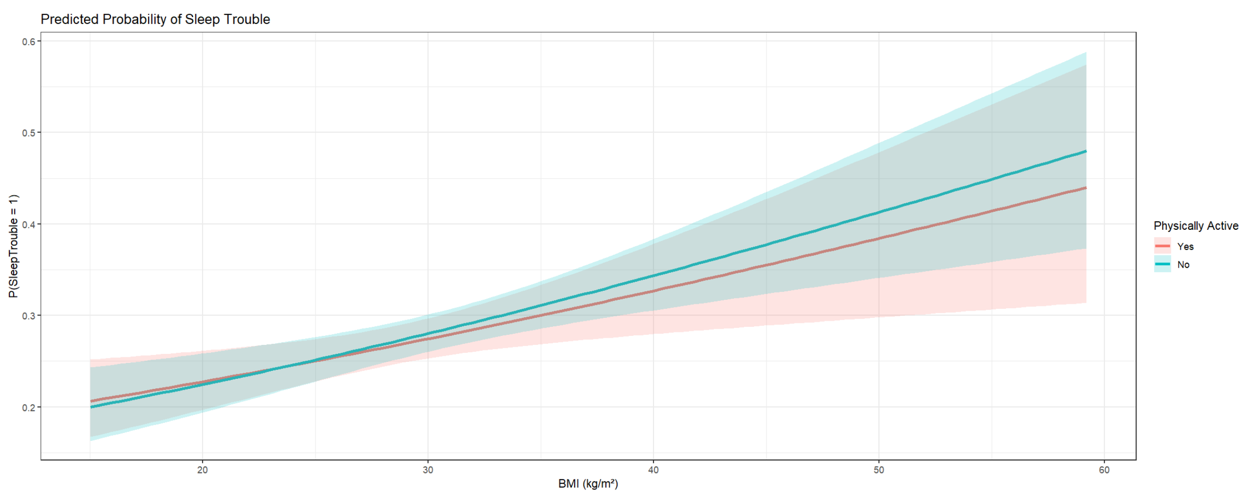

Figure 4 Predicted probability of sleep trouble as a function of BMI and physical activity status, based on Model M3. Lines are nearly parallel, indicating no significant interaction effect

Discussion and Conclusion

Interpretation

The results of this study support the primary hypothesis that higher BMI is significantly associated with increased odds of reporting sleep trouble in adults over the age of 30. This finding was robust across both descriptive and inferential analyses, including a significant effect in the first adjusted logistic model (M1) and consistent differences in average BMI between sleep trouble groups. However, the secondary hypothesis—that physical activity would moderate this association—was not supported. The interaction term between BMI and physical activity was not statistically significant, and the predicted probability plot showed no appreciable difference in sleep trouble risk between active and inactive participants across the BMI spectrum.

Public Health Implications

These findings reinforce the importance of body weight as a modifiable risk factor for sleep disruption. While physical activity is widely recommended for metabolic and psychological health, it did not appear to buffer the effect of high BMI on sleep trouble in this sample. This suggests that, at least in the context of self-reported physical activity and sleep trouble, excess body weight may independently elevate risk. Public health messaging aimed at improving sleep outcomes may benefit from emphasizing weight control in addition to general activity promotion.

Limitations

This study has several limitations. First, the data are cross-sectional, meaning we cannot infer causality between BMI and sleep trouble. Second, both sleep trouble and physical activity were measured through self-report, which may introduce bias or misclassification. Third, the analysis did not control for other potential confounders such as depression, medication use, or chronic illness, which are known to influence both sleep and weight. Finally, the sample excludes individuals under 30 and may not generalize to younger populations.

Conclusion and Future Directions

In conclusion, BMI was a significant predictor of sleep trouble among adults over 30, but the hypothesized moderating effect of physical activity was not observed. These findings highlight the importance of addressing obesity as a contributor to sleep-related problems. Future research should incorporate objective measures of both sleep and activity, explore longitudinal associations, and consider additional psychosocial and medical factors to better understand the complex relationship between weight, lifestyle, and sleep health.

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