Path to Quality Sleep: A Panel Analysis

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Abstract:
This paper determines the relationships between physical activity, stress, and sleep quality among retirees in the United States. Using longitudinal data from the Health and Retirement Study (1992-2022), this analysis examines how physical activity influences sleep quality through reduced chronic stress. Transitioning into retirement introduces new stressors that may negatively affect sleep quality. While previous research shows that physical activity provides mental health benefits (Manyou et al., 2025; Puett et al., 2020), its indirect effects on sleep through stress reduction among retirees remain underexplored. Using fixed-effect logit models, results suggest that higher levels of physical activity are significantly associated with lower levels of stress and less restless sleep. Physical activity reduces the likelihood of sleep issues by 6-13%, and higher chronic stress increases the odds by about 37%. Because stress and health are closely linked to healthcare utilization, these findings suggest that promoting physical activity among retirees may help reduce medical expenditures by improving stress regulation and sleep quality. Mediation would imply that a small part of the effect of physical activity on sleep operates through reductions in stress.

Introduction:
Entering retirement is a large transition that changes both the economic and social structure of an individual's life. Retirees often face changes in income, time management, and a structured routine, all of which affect their overall well-being. The loss of structure and changes in roles can elevate stress levels and alter sleep patterns. This outlines a key tradeoff, because retirees gain more time for leisure activities, but they also face health, age, and budget-related constraints that may influence how they allocate their time. From an economic perspective, retirement is a critical period for investments in health. As individuals age, it becomes increasingly important to maintain good health and prevent expensive medical interventions. Chronic stress plays an important role in this issue because it is strongly associated with worse health and increased utilization of healthcare. Because stress and health are related, behaviors that reduce stress can help improve one's health while lowering future medical costs. This is especially relevant for retirees because as they gain more time to allocate towards leisure activities, they also face constraints related to age, health, and expenses.

Physical activity has been widely recognized for its health benefits, including its positive effects on overall mental health. Retirees must decide how to allocate their additional available time across activities, including physical activity, under these constraints. There are clear relationships between physical activity, stress, and sleep, but the pathway connecting these factors is underexplored. Additionally, there is a lack of research specifically targeting retired individuals. Being able to pinpoint how physical activity affects stress and sleep can inform policies aimed at improving the well-being of adults. Understanding this pathway can enhance the effectiveness of existing physical and mental wellness programs for retirees.

This research should help address this gap by empirically examining the relationships between physical activity, stress, and sleep quality among retired individuals. This paper addresses the following question: "How does physical activity affect sleep quality in retired individuals?" I hypothesize that physical activity is both directly associated with better sleep quality and indirectly associated via reductions in chronic stress.

Literature Review

After thoroughly reviewing the existing literature, several key findings stood out. De Nys et al. (2021) found that physical activity is an effective strategy for lowering cortisol levels (stress hormone) and improving overall sleep quality. Additionally, this study highlights the numerous mental health benefits that adults derive from engaging in regular physical activity. Manyou et al. (2025) conducted a systematic review and concluded that there is a negative correlation between physical activity and mental health issues. Both diagnosed and self-reported mental health populations showed similar outcomes regarding the benefits of physical activity. This literature suggests a plausible pathway where physical activity reduces stress, which in turn improves sleep quality and long-term health outcomes. Because retirees face age-related constraints and more sleep problems, the ability for physical activity to reduce stress is vital in this population.

It is important to identify the relationship between stress and potential control variables. For example, gender differences are likely to affect the severity of stress and different styles of coping. Matud (2004) hypothesized that women experience more stress than men and are more likely to use emotional coping strategies in the paper, "Gender differences in stress and coping styles." In "The impact of pre-existing conditions and perceived health status on mental health during the COVID-19 pandemic", Buneviciene et al. (2021) found that people with pre-existing health conditions combined with poor perceived health show higher levels of overall distress. Additionally, Mckenize et al. (2025) found that stress can reduce an individual's motivation for healthy lifestyle behaviors, and, in turn, a poor lifestyle can increase stress. This suggests potential simultaneous causality, as stress and healthy lifestyle behaviors influence each other simultaneously. The association between health status and stress implies that age-related medical costs could be reduced by encouraging engagement in physical activity and, therefore, decreasing stress. Economically, this suggests that stress is not just an outcome, but also a determinant in how health behaviors affect medical spending in the long run, which makes it crucial for understanding health investments that can be cost saving among the retired population. These findings justify the inclusion of gender and health status as control variables because both are strongly associated with stress and individual behaviors.

Data & Methods

The data for this study were obtained directly from the Health and Retirement Study (HRS): Longitudinal File 2022, which compiles data collected from 1992 to 2022. This is a longitudinal panel study that surveys a representative sample of respondents who are aged 50 years and older, meaning that respondents are either nearing or have already entered retirement. There are sixteen waves within this data set, where each wave is two years.

These records include any individual who has ever completed an HRS Core Interview. In household couples, data is collected from both the respondent's and the spouse's responses. To align with the research focus on retirees, only respondents who are retired were retained in the sample, while those who are currently working for pay were excluded. Because the analysis aims to capture change over time, only individuals in three or more waves (six or more years) were included. Spouse records were excluded to avoid potential overlapping or confounding that may arise from household data.

Variables:

freqPA: equals 1 if the respondent engages in physical activity more than once a week and equals 0 if less than once a week

intensityPA: equals 1 for moderate/vigorous activity and 0 for light/no activity

stress: recoded from the HRS variable rlbonchrstr (chronic strain); it measures chronic stress based on responses to eight yes or no questions. Each "yes" indicates a stressor in a respondent's life. Answering "yes" to none of those questions indicates the respondent has no stress, and "yes" to one or more questions indicates stress. These questions relate to various domains, including financial issues and relationships. Coded as 1 if the respondent reports no chronic stress and 2 if one or more stressors are reported. For interpretation, higher values of this variable indicate greater chronic stress.

restless: primary outcome variable which represents the degree in which respondents record difficulty sleeping and/or restless nights of sleep.

health: represents self-reported health status; higher values represent worse health (1 = excellent; 2 = very good; 3 = good; 4 = fair; 5 = poor)

wave: time control variable; indicates which survey wave(s) in which the response was recorded

age: respondents age (in years)

gender: male and female (1 = male; 2 = female)

race: categorical race variable (1 = White/Caucasian; 2 = Black/African American; 3 = Other)

Table 1. Summary Statistics for Retiree Sample (HRS 1992–2022)

	Mean	Std. Dev.	Min	Max	N
restless	0.308	0.462	0.00	1.00	66852
freqPA	0.669	0.471	0.00	1.00	60322
intensityPA	0.754	0.431	0.00	1.00	60245
stress	1.010	0.099	1.00	2.00	18712
health	3.014	1.076	1.00	5.00	71414
age	71.289	8.632	27.00	103.00	71484
gender	1.518	0.500	1.00	2.00	135193
race	1.268	0.546	1.00	3.00	135055

Table 1 shows that around 31% of retirees experience restless sleep, and about two-thirds engage in physical activity more than once a week. Gender and race are included as controls to account for potential differences in health outcomes and access to health resources that may influence other variables. It is hypothesized that higher levels of physical activity will be associated with less restless sleep and lower stress, which improves sleep. Stress and poor self-reported health are expected to be negatively correlated with sleep quality/positively correlated with restlessness.

To examine the relationship between physical activity, stress, and sleep quality, different econometric models were used. Because the dependent variable (restless sleep) is binary, logit/probit models are used as the primary specification, and OLS is used to verify the robustness of the results. The logit helps capture nonlinear relationships between variables as well as the probabilities (odds ratios) associated with each connection. Additionally, OLS regressions were conducted to solidify the mediating effect of chronic stress by examining individual relationships between variables.

The preferred method is a fixed-effect logit model, which controls individual-specific time heterogeneity. This ensures that unobserved factors do not bias the results, and it allows for individual comparisons over time, parallel to the longitudinal structure of the HRS. The models test a few relationships. First, the direct effect of physical activity (frequency and intensity) on restless sleep. Next, the mediating role of stress, where physical activity may reduce stress and improve sleep quality. Lastly, controlling for self-health, age, gender, and wave (year) creates a robust model.

Theoretical Model:
The guiding factor in this analysis is based on the idea that physical activity influences sleep quality both directly and indirectly through stress as a mediator. The underlying idea is that higher frequency and intensity of physical activity reduce stress levels, which in turn improves sleep quality. This means that physical activity can mitigate the effects of stress, which affects well-being.

$$\text{Model: } Sleep_{it} = \beta_0 + \beta_1 PA_{it} + \beta_2 Stress_{it} + \beta_3 Health_{it} + \beta_4 Race_i + \beta_5 Gender_i + \beta_6 Age_{it} + \alpha_i + \lambda_t + u_{it}$$

- i = individual person
- t = wave (2-year span)

In this model, $Sleep_{it}$ (restless sleep) is the dependent variable, PA_{it} (frequency and intensity) measures physical activity, and $Stress_{it}$ is the potential mediating variable. The control variables are $Health_{it}$, Age_{it}, $Race_i$, and $Gender_i$. The terms α_i (alpha) and λ_t (lambda) are for the unobserved individual and time-specific effects. Identification relies on changes over time, where individual fixed effects control for variables including baseline health and preferences, which are unobserved time-invariant characteristics.

The model is designed to capture the direct effect of physical activity on sleep and the indirect effect that operates through stress. Therefore, this model predicts that greater frequency and intensity of physical activity will lead to improved sleep quality in retirees, both directly and indirectly through reducing chronic stress. Including self-reported health is important because stress and health both help predict medical utilization. By controlling for health, the role of physical activity in reducing stress and restless sleep can be isolated.

This model relies on a few standard assumptions. The first being that the error term has a mean value of zero and is uncorrelated with the independent variables. The model also assumes physical activity is exogenous after controlling for the observable controls. Additionally, perfect multicollinearity is not present among variables. There is a potential threat to internal validity through reverse causality, as poor sleep may be a reason for someone to engage in physical activity less. The individual fixed effects help mitigate bias, but time-variant factors may still influence physical activity and sleep.

Empirical Results & Interpretations
Table 2 presents four fixed-effect logistic models, each with restless sleep as the outcome variable. Model (1) examines only the effects of frequency of physical activity on sleep. The odds ratio of 0.894 indicates that more frequent physical activity reduces the odds of experiencing restless sleep by about 11%, and this effect is statistically significant.

Model (2) does not include frequency and instead examines the relationship between physical activity intensity and sleep. More intense physical activity (moderate to vigorous) reduces the odds of experiencing restless sleep by about 18% (highly significant). Model (3) includes both frequency and intensity of physical activity in the equation. While both remain statistically significant, intensity has a stronger effect, suggesting that the intensity of physical activity plays a stronger role than frequency. Including both physical activity measures in the model changes the odds ratios slightly as well. We now see that more frequent physical activity reduces restless sleep by 6% while more intense physical activity reduces restless sleep by about 16%.

Model (4) introduces stress into the model and is the preferred specification. This model illustrates that frequency and intensity of physical activity have lost their statistical significance, but the effects are very similar. The odds ratios (0.94 and 0.87) imply that retirees engaging in more frequent or more intense physical activity are 6-13% less likely to experience sleep disturbances. Stress emerges as a strong and highly significant predictor of restless sleep. Because higher values of the stress variable indicate more chronic stress, odds ratios larger than one show an increased likelihood of restless sleep. According to the results, retirees with stress have about 37% higher odds of experiencing restless sleep. This result confirms that stress is a potential mediating variable in the relationship between physical activity and sleep. Self-reported health is strongly associated with restless sleep across all four specifications. Retirees who report poor health have about four times higher odds of experiencing restless sleep compared to those reporting excellent health.

Table 2: Fixed-Effects Logistic Regression — Odds Ratios

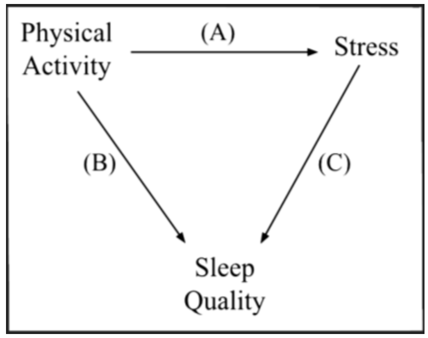
	(1) restless	(2) restless	(3) restless	(4) restless
freqPA	0.894^{***}		0.941^{*}	0.937
	(0.001)		(0.096)	(0.443)
intensityPA		0.820^{***}	0.839^{***}	0.865
		(0.000)	(0.000)	(0.122)

stress				1.368***
				(0.000)
1.health	1.000	1.000	1.000	1.000
	(.)	(.)	(.)	(.)
2.health	1.106	1.106	1.107	1.006
	(0.198)	(0.196)	(0.193)	(0.972)
3.health	1.444***	1.441***	1.441***	1.572**
	(0.000)	(0.000)	(0.000)	(0.012)
4.health	1.980***	1.958***	1.953***	2.343***
	(0.000)	(0.000)	(0.000)	(0.000)
5.health	3.146***	3.091***	3.073***	3.811***
	(0.000)	(0.000)	(0.000)	(0.000)
N	30091	30033	30033	5213
r2_p	0.013	0.014	0.014	0.032

Robust standard errors in parentheses. Odds ratios are exponentiated coefficients.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The pseudo-R² of 0.014 (in Model (2)) indicates that this model improves the prediction by 1.4% relative to the null. This is within the typical range for a fixed-effects model using panel data. Although this is a modest measure, the statistical and practical significance of the coefficients suggest an economically meaningful impact. The impact is that relatively small increases in intense physical activity can lead to notable improvements in sleep quality. The practical implication here is that improved sleep among retirees could reduce healthcare costs and enhance quality of life.

Determining the indirect effect of physical activity on sleep through reductions in stress can be used as a robustness check. To show this, we need to examine the relationships between variables individually: physical activity and stress, physical activity and sleep, and stress and sleep. Because there is so little variation in the stress variable, fixed-effects logistic models are not feasible, thus, we will run standard Ordinary Least Squares (OLS) regression. Although stress and sleep are binary outcomes, OLS can be used as a robustness check to similarly illustrate the direction and magnitude of the relationships found in the logit. Race and gender are included in the OLS models to account for potential bias. We expect the same relationship between variables as seen in Model 1. Below, A represents the effect of physical activity on stress, B is the direct effect of physical activity on sleep, and C is the effect of stress on sleep.



First, we will be examining Path A, which models the relationship between physical activity and stress. Based on the literature and our logit model results, we expect that more frequent and intense physical activity will reduce stress (negative correlation). Table 3 shows a negative correlation between variables, suggesting that physical activity decreases stress even when examined independently. It is also important to note that more intense physical activity (as opposed to more frequent physical activity) has a more significant negative correlation with stress. Additionally, we accounted for health, race, and gender in each of the pathway models, but these variables will not be displayed in the Tables for simplicity.

Table 3: Pathway(A) Panel Regression

	(1) stress
freqPA	-0.006
	(0.416)
intensityPA	-0.071***
	(0.000)
age	-0.005***
	(0.000)
_cons	0.535***
	(0.000)
N	18662
r2_p	

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Next, we will examine Path B, which is the relationship between physical activity and sleep quality. We expect a negative correlation in our OLS results as well, which will solidify our findings from the logit model. Based on the results, we find yet another negative correlation, further indicating that physical activity negatively impacts restless sleep. In other words, more physical activity (both higher frequency and intensity) is correlated with less restless sleep.

Table 4: Pathway(B) Panel Regression

	(1)

	restless
freqPA	-0.013***
	(0.005)
intensityPA	-0.036***
	(0.000)
age	-0.004***
	(0.000)
_cons	0.487***
	(0.000)
N	56463
r2_p	

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Lastly, we will examine Path C, which models the effect of stress on sleep quality. For this relationship, we expect a positive correlation, indicating that stress is positively correlated with restless sleep. Based on the OLS results, we see a positive correlation similar to what was found in the logit model.

Table 5: Pathway(C) Panel Regression

	(1)
	restless
stress	0.091***
	(0.000)
age	-0.004***
	(0.000)
_cons	0.384***
	(0.000)
N	18355
r2_p	

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Discussion

The results are consistent with the proposed hypothesis and overall expectations. The findings from Table 2 further the idea that higher levels of physical activity are directly and indirectly associated with better sleep quality. This aligns with the framework that suggests physical activity mitigates stress and promotes better sleep. The results help solidify the understanding that stress adds a potentially mediating effect but does not diminish the effect of physical activity on sleep alone.

The results also align with and greatly add to the existing literature. The main findings complement the paper titled "The Effects of Physical Activity on Cortisol and Sleep," which reports that exercise lowers stress hormone levels and enhances sleep quality. It also aligns with work by Puett et al. (2020), who found that being physically inactive correlates with poorer mental health outcomes among older adults. The relationships that were observed between stress, health, and sleep support the findings of Buneviciene et al. (2021) that individuals with high stress and poor perceived health have greater psychological distress. The parallels between past literature and this research reinforce the understanding that physical activity promotes mental and physical well-being, even in retired individuals. Additionally, the relationship between health status and stress implies that greater physical activity among retirees would reduce medical costs.

Clear economic implications appear based on the results. Chronic stress and poor sleep are associated with worse health and increased medical utilization among retirees. Physical activity has been shown to reduce stress and improve sleep, which can help retirees maintain longer-term health and prevent costly medical interventions. Encouraging physical activity is a low-cost intervention that can improve retirees' quality of life and reduce healthcare expenses.

Several limitations should be noted, despite these findings. Because physical activity and sleep quality are self-reported, there is a possibility of bias and/or measurement error. Additionally, time-varying factors, including changes in health and life events, may influence the variables, which could pose a threat to internal validity. Reverse causality is another notable concern because poor sleep could affect an individual's likelihood of being physically active. While the results provide strong evidence of correlation, these limitations should be considered when interpreting the estimates.

Conclusion

This study provides evidence that physical activity plays a large role in quality sleep among retirees, both directly and indirectly. Using longitudinal data from the HRS and constructing fixed-effect regression models, results indicate that physical activity, particularly more intense, is associated with a lower likelihood of experiencing restless sleep. Stress emerges as a mediating factor as it is consistently linked to more restless sleep and is mitigated by physical activity.

Some practical implications can be made from the findings of this study. Encouraging physical activity, particularly moderate to vigorous activity, can serve as an effective strategy to improve sleep and reduce stress in the retired population. This can help enhance quality of life and lower healthcare burdens later in life. This research contributes to the literature by examining the indirect pathways through which behaviors affect sleep outcomes. Furthermore, it emphasizes the importance of wellness interventions that address physical and mental health. Future research should investigate potential variations across gender and socioeconomic status to refine interventions aimed at promoting retiree well-being.

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