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ASSOCIATION OF PHYSICAL ACTIVITY WITH DEPRESSION ACROSS DIFFERENT RACES IN ADULTS: INSIGHTS FROM NHANES2015–2018 DATA

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Abstract

Depression is an affective disorder that brings an economic and emotional burden to individuals and society. This study explored the association between the types of physical activity and the risk of depression, evaluating racial disparities in physical activity levels among adults. Data from the 2015–2018 National Health and Nutrition Examination Survey (NHANES) were utilized, encompassing 2,111 adults. Key variables considered were demographics, physical activity, and depression, as measured by the Physical Activity Questionnaire and the PHQ-9 depression scoring system. Out of the five physical activity categories, vigorous work, moderate work, and walking and cycling activities showed no significant correlation with depression risk. In contrast, moderate recreational and vigorous recreational activities appeared to offer protective effects against depression. Non-Hispanic black individuals notably benefited from moderate recreational activities ($p = 0.021$) in lowering their depression risk. For Non-Hispanic whites, engaging in vigorous recreational ($p = 0.004$) and moderate recreational ($p = 0.002$) activities were advantageous in depression prevention. Among Mexican Americans and "other racial categories", the five types of physical activities did not significantly reduce depression risk. The results suggest that engaging in physical activity can reduce the risk of depression. However, the benefits vary among racial groups based on the intensity and type of physical activity. These results can help inform mental health professionals when making recommendations to patients from different racial groups. Future research should look at the reasons behind the differences among the groups.

Keywords: *physical activity, depression, race, NHANES, PHQ-9*

Introduction

Depression, a widespread mental disorder, is characterized by persistent sadness and a loss of interest in activities previously found enjoyable. This condition not only affects individuals emotionally but also places significant

strain on families and society. The economic implications of depression are profound, including direct medical costs, losses from workplace disruptions like absenteeism, and indirect costs from suicides. In 2018, the economic burden of major depressive disorder in the U.S. reached an estimated $236 billion, a rise of over 35% since 2010 (American Psychiatric Association, 2021). While people suffer from depression, many are not given proper treatment. Data from the National Health and Nutrition Examination Survey, a survey research program that aims to assess the health and nutritional status of adults and children in the United States, provides the opportunity to delve deeper into the topic of the relationship between physical activity and depression, and influence that different racial groups bring to the study result.

Depression coexists with various health issues, including tuberculosis, cardiovascular diseases, and sleep disturbances. Moreover, those with depression often contend with chronic conditions such as arthritis, heart disease, diabetes, stroke, and cancer. While depression can cause physical symptoms and increase the risk for physical illnesses or conditions, illnesses can in turn trigger depression and make the situation worse (Stuart, 2022). Data from the National Library of Medicine indicate that the prevalence of depression increased from 7.3% in 2015 to 8.6% in 2019, suggesting that almost one in 12 U.S. residents experience this disorder (Goodwin et al., 2022). Research has consistently shown a strong association between depression, increased suicide risk, and reduced quality of life (Sakashita & Oyama 2019; Dhar & Barton 2016).

When people exercise, hormones called endorphins are released and reduce the perception of pain by interacting with neurons that respond to pain. Moreover, endorphins act as sedatives, which help reduce stress and anxiety and improve sleep quality (Bruce, 2022). Doing physical activities has been shown to be helpful in reducing depression and making people feel better. The biological benefits of physical activity make it a good option for people to select when coping with their mental issues.

Hallgren et al. carried out a study involving 24,060 participants that demonstrated that replacing sedentary behavior with light to moderate-to-vigorous work activity significantly reduced the risk of depression (Hallgren *et al.*, 2020). An examination of the bidirectional relationship between physical activity and depression in 611,583 adults endorsed the potential of physical activity as a preventive measure against depression (Choi et al., 2019). A meta-analysis emphasized the mental health benefits of physical activity for adults, even when undertaken below the recommended levels for public health (Pearce et al., 2022). Analysis of NHANES data from 2011–2014 indicated that leisure-time physical activity was particularly effective in alleviating depression among US adults (Rutherford et al., 2022). Furthermore, researcher Dina found that the benefits of exercise and physical activity on depressive symptoms were on par with antidepressant treatments (Dinas et al., 2011).

Investigations into the effects of physical activity on depression in both adults and adolescents concluded that regular activity considerably reduces depression risk (Bailey et al., 2018). Dr. Aan Het Rot confirmed the positive correlation between physical activity and enhanced mental well-being in adults (Aan Het Rot et al., 2009). Emerging evidence suggests that even minimal amounts of physical activity can act as a safeguard against depression (Teychenne et al., 2008). Research focusing on older adults highlighted that various forms of exercise, including aerobic, resistance, and mind-body exercises, were linked to fewer depressive symptoms (Zhang et al., 2021). Lastly, Mumba et al. found that both vigorous and moderate recreational physical activities had notable effects on depression scores among older adults (aged 50 and above) (Mumba et al., 2021). It further mentioned the importance of considering the potential differences between various racial groups, which aligns with one of the focuses of our study.

While numerous studies have explored the impact of physical activity on depression, many focus on the effects of physical activity on depression, together with other mental disorders and diseases. A few researchers take the five physical activity levels as a standard for research and directly study the relationships between the time of doing physical activities and the chance of suffering from depressive symptoms. Moreover, there remains a limited body

of research examining the differential effects across different racial groups in the US. Given the substantial socio-economic and health disparities among these groups, the influence of physical activity on depression in the general population may not directly apply to specific racial demographics. Hence, it becomes imperative to evaluate how different types of physical activity affect depression within each racial group.

Methods

Data Collection & Analysis

This research utilized data sourced from the National Health and Nutrition Examination Survey (NHANES), a nationally representative cross-sectional survey orchestrated by the Centers for Disease Control and Prevention (CDC). NHANES employs a stratified multistage design rooted in random sampling techniques. Trained interviewers gathered questionnaire data in participants' homes. Meanwhile, the mobile examination center (MEC) phlebotomists collected blood samples. These samples were subsequently refrigerated or frozen and dispatched to laboratories for analysis. Additionally, the MEC managed physical examinations. The current analysis uses data from the NHANES cycles of 2015–2016 and 2017–2018.

Out of the 11,268 participants in the NHANES2015–2018 cohort, exclusions were made for those under 20 years old (529 participants) and those with indeterminable depression statuses (1,066 participants). The NHANES review process further omitted entries with missing, rejected, or ambiguous data on physical activity and sedentary time, as well as those reporting over 24 hours, encompassing total physical activity time, sedentary periods, and sleep duration. Participants with absent or rejected covariates were also excluded (7,562 in total). Ultimately, a refined cohort of 2,111 participants, with comprehensive data on primary outcomes, exposure, and relevant variables, was retained for analysis.

Definition of Major Depression and Physical Activities

For the purposes of this research, participants were classified as having depression based on their responses to the PHQ-9 questionnaire (Lagerros et al., 2006); specifically, if they completed all items and achieved a threshold score.

Physical activity patterns were ascertained using the Global Physical Activity Questionnaire (Lagerros et al., 2009). Physical activities were delineated into five categories, determined by participants' responses:

Vigorous Work Activity: Defined as tasks that cause a pronounced increase in breathing or heart rate for an extended period. Vigorous Recreational Activities: including leisure, fitness, and high-intensity sports that result in a significant escalation in respiration or heart rate. Moderate Work Activity: Activities characterized by a modest elevation in breathing or heart rate. Moderate Recreational Activities: Activities inducing a light rise in respiratory or heart rate for a set duration. Walking or Bicycling: Engaging in either of these for transportation purposes, such as commuting to work, school, or shopping. The reported activity durations were aggregated to calculate the cumulative physical activity duration. This was derived from the multiplication of the frequency and duration of each physical activity type reported by participants.

Covariates

Data was collected using a structured household questionnaire, capturing gender (male, female), age, education level (Less than high school, HS grad/GED, Some college/AA, College/above), marital status (categorized as married or unmarried, with the latter encompassing widowed, divorced, separated, never married, and cohabiting), race (categories included Mexican American, Non-Hispanic Black, Non-Hispanic White, and other races), and employment status from the previous week. Smoking history was ascertained with the question, "Have you smoked at least 100 cigarettes in your entire life?" (yes/no). Body Mass Index (BMI) was calculated by dividing weight (kg) by the square of height (m^2). Hypertension status was determined based on self-reported diagnosis, antihypertensive medication use, or if measured blood pressure exceeded specified thresholds (systolic ≥ 140 mm Hg and/or diastolic ≥ 90 mm Hg).

Statistical Analysis

The baseline characteristics of participants were categorized by depression status.

Descriptive statistical analyses were applied to demographic data (such as gender, age, education level, race, marital status, and employment), behavioral metrics (like total physical activity duration), body measurements (specifically, BMI), and medical conditions (such as hypertension and obesity). Categorical variables were expressed as frequency (%), and chi-square tests were used for non-ordinal categorical variables. Continuous variables were presented as mean ± standard error, with the Student's t-test determining statistical relevance. Considering the multistage sampling design and oversampling, we employed MEC weights in our models, supplemented with variables for primary sampling units (PSUs) and the Masked Variance Unit Pseudo-stratum. These weight variables enable generalization to the entire civilian noninstitutionalized US population. The association between depression risk and physical activity was examined through weighted logistic regression models. Odds ratios (ORs) with 95% confidence intervals (CIs) were provided, along with p-values to assess the association's magnitude and significance. Multivariable logistic regression models, inclusive of demographics, behaviors, and medical conditions as covariates, were devised to adjust for potential confounders. A p-value below .05 was deemed statistically significant. All computations were executed in the R software.

Results

Table 1 shows the sample characteristics of a total of 2111 respondents between the years 2015–2018. Overall, depression is more common in females (12.9%) than males (7.4%, p-value = 0.0097). Participants who answered "Yes" to smoking were more likely to have major depression than those who did not smoke (15.6% vs 4.7%, p-value, 0.0001). Major depression was more likely to occur among participants with normal weight (12.7%), without a job or business (13.3%), and lowest poverty income ratio (16.3% for PIR < 1.3). There were no significant differences between participants with or without depression for hypertension and total physical activity time.

Table 1. *Sample characteristics of demographics, medical conditions, and physical activities by depression status*

		Depression status				
		No		Yes		p value
		n(%)	SE	n(%)	SE	
Hypertension	No	1223(91.2)	1.1	124(8.8)	1.1	0.1727
	Yes	682(88.4)	1.9	82(11.6)	1.9	
Gender	male	1268(92.6)	1.8	104(7.4)	1.8	0.0097
	Female	637(87.1)	0.9	102(12.9)	0.9	
Smoking status	No	1044(95.3)	0.8	65(4.7)	0.8	<0.0001
	Yes	861(84.3)	1.7	141(15.6)	1.7	
Obesity status	Normal/underweight	818(87.3)	1.6	108(12.7)	1.6	0.0206
	Obesity	22(97.1)	3.2	1(2.9)	3.2	
	Overweight	1065(92.8)	1.1	97(7.2)	1.1	
employment	Looking for work/not working	847(86.7)	1.5	131(13.3)	1.5	<0.001
	With a job or business	1058(92.7)	1.1	75(7.3)	1.1	
Poverty level	<1.3	623(83.7)		106(16.3)		<0.001
	1.3~3.5	799(89.7)		78(10.3)		
	>3.5	483(95.4)		22(4.6)		
		mean	SE	mean	SE	
Physical activity time (minutes)		1007.2	39.8	890.9	116	0.358

Note: SE = standard error, poverty level <1.3 = poverty, 13.~3.5 = normal, >3.5 = rich

Table 2 shows the crude (univariable logistic regression) and adjusted (multiple logistic regression) models of various physical activity types as predictors and depression as the outcome. In the crude univariable logistic regression model, physical activities such as vigorous and moderate work activities were not significantly associated with depression (OR and 95% CI, 0.95 [0.55,1.58], p-value = 0.8104 for vigorous work activities; OR and 95% CI, 1.09[0.76,1.55], p-value = 0.6561 for vigorous work activities). Similarly, in multiple logistic regression models adjusted for other covariates, the odds ratios (OR) for vigorous (OR = 0.74, 95% CI = [0.42, 1.32], p-value = 0.3276) and moderate work activities (OR = 0.98, 95% CI = [0.66, 1.45], p-value = 0.9189) were not significantly associated with depression. Walk or bicycle activities were significantly associated with depression (p-value = 0.0066), with an OR of 1.64 (95% CI = [1.18, 2.30]), indicating having walk or bicycle activities was associated with depression. However, after adjusting for other covariates, the association between walking or bicycle activities and depression was attenuated (OR = 1.37, 95% CI = [0.95, 1.96], p =0.1072). Vigorous recreational activities were significantly associated with depression (OR = 0.46 95% CI = [0.28, 0.75], p-value = 0.0041) in the crude model. As in the multiple logistic regression models, the relationship between depression and vigorous recreational activities is still significant, with odds ratios of 0.48 (95% CI [0.31, 0.73], and p-value = 0.0037).

Table 2. *Associations Between Individual Types of Physical Activities and Depression: Crude and Adjusted Logistic Regression Models*

	Crude model		Adjusted model	
Type of PA	**OR[LCI, UCI]**	**p value**	**OR[LCI, UCI]**	**p value**
Vigorous work	0.95 [0.55,1.58]	0.8104	0.74 [0.42, 1.32]	0.3276
Moderate work	1.09[0.76,1.55]	0.6561	0.98[0.66, 1.45]	0.9189
Walk or Bicycle	1.64[1.18, 2.30]	0.0066	1.37[0.95,1.96]	0.1072
Vigorous Recreational	0.46[0.28,0.75]	0.0041	0.48[0.31,0.73]	0.0037
Moderate Recreational	0.39[0.27, 0.58]	<.001	0.47[0.32,0.71]	0.0024

Note: OR = odds ratio, LCI = lower confidence intervals, UCI = upper confidence intervals

The subgroup analysis of the association between various physical activity types and depression by race groups in multiple logistic regression models is shown in Table 3. The vigorous work activities do not have a significant protective effect on depression among Mexican-American groups (OR=0.44, 95% = = [0.44,1.25], p-value = 0.122). Similarly, vigorous work activities influence Non-Hispanic black (OR = 0.64, 95% = [0.64, 1.85], p-value = 0.409), white (OR = 0.75, 95% = = [0.75, 1.48], p-value = 0.413) and other races (OR = 0.48, 95% = [0.84, 1.79], p-value = = 0.643) group respectively by decreasing the possibilities of getting depression. However, none of the associations between vigorous work activities and depression were statistically significant.

Table 3. *Associations Between Individual Types of Physical Activities and Depression: subgroup analysis by racial groups*

	Mexican American		Black	
Type of PA	**OR[LCI, UCI]**	**p value**	**OR[LCI, UCI]**	**p value**
Vigorous Work	0.44[0.44, 1.25]	0.122	0.64[0.64, 1.85]	0.409
Moderate Work	1.46[1.46, 5.24]	0.561	1.21[1.21, 2.47]	0.592
Walk or Bicycle	0.27[0.27, 2.26]	0.225	1.32[1.32, 2.46]	0.384
Vigorous Recreational	1.43[1.43, 5.30]	0.594	0.45[0.45, 1.14]	0.093
Moderate Recreational	1.36[1.36, 4.74]	0.631	0.42[0.42, 0.88]	0.021

Type of PA	White OR[LCI, UCI]	p value	Other OR[LCI, UCI]	p value
Vigorous Work	0.75[0.75, 1.48]	0.413	0.84[0.84,1.79]	0.643
Moderate Work	0.88[0.88, 1.45]	0.629	1.24[1.24, 2.87]	0.607
Walk or Bicycle	1.65[1.65, 2.77]	0.58	0.76[0.76, 1.97]	0.572
Vigorous Recreational	0.48[0.48, 0.79]	0.004	0.35[0.35, 1.04]	0.059
Moderate Recreational	0.37[0.37, 0.68]	0.002	0.99[0.99, 2.10]	0.975

Note: PA = physical activity, OR = odds ratio, LCI = lower confidence intervals, UCI = upper confidence intervals

For moderate work activities, Non-hispanic white is the only group that shows protective effect of moderate work activities(OR = 0.88, 95% = [0.88, 1.45], p value = 0.629). Whereas among Mexican Americans (OR = 1.46, 95% = [1.46, 5.24], p-value = 0.561), Non-Hispanic blacks (OR = 1.21, 95% = [1.21, 2.47], p-value = 0.592) and other races(OR = 1.24, 95% = [1.24, 2.87], p-value = 0.607), moderate work activities increased the likelihood of getting depression. However, moderate work activities were not a significant factor for depression.

Walking and cycling activities are not significantly associated with depression in Mexican American(OR = 0.27, 95% = [0.27, 2.26], p-value = 0.225) and Non-hispanic white(OR = 1.65, 95% = [1.65, 2.77], p-value = 0.58). Meanwhile, non-hispanic black(OR = 1.32, 95% = [1.32, 2.46], p-value = 0.384) and other races(OR = 0.76, 95% = [0.76, 1.97], p-value = 0.607) are relatively less associated by walking and cycling activities in depression.

The vigorous recreational activities are not significantly associated with depression in Mexican Americans (OR = 1.43, 95% = [1.43, 5.30], p-value = 0.594), Non-Hipanic Black (OR = 0.45, 95% = [0.45, 1.14], p-value = 0.093), and Other racial groups(OR = 0.35, 95% = [0.35, 1.04], p-value = 0.059). However, in the Non-Hispanic White group, vigorous recreational activities are significantly associated with a lower likelihood of having depression (OR = 0.48, 95% = [0.48, 0.79], p-value = 0.004).

Moderate recreational activities are significantly reducing the likelihood of having depression among Non-Hispanic White (OR = 0.37, 95% = [0.37, 0.68], p-value = 0.002) and Non-Hipanic Black (OR = 0.42, 95% = [0.42, 0.88], p-value = 0.021). While in Mexican American and other racial groups, the associations between moderate recreational activities and depression were not statistically significant (OR = 1.36, 95% = [1.36, 4.74], p-value = 0.631 and OR = 0.99, 95% = [0.99, 2.10], p-value = 0.975 for Mexican American and Other races respectively).

Discussion

The primary objective of this research was to examine the association between various forms of physical activity (including vigorous work-related activity, vigorous recreational activities, moderate work activity, moderate recreational activities, and walking/bicycling) and the prevalence of depression. In addition, considering potential racial disparities in the susceptibility to depression, this study delved deeper into the moderating effect of race on the relationship between the mentioned physical activities and depression.

To the best of my knowledge, this is the first study that studies the variable effects of physical activities on different racial groups. The findings indicate that specific physical activities can either reduce or amplify the risk of depression among the four racial groups analyzed. For instance, in Mexican Americans, even though the results weren't statistically significant, engaging in vigorous work activities, as well as walking and bicycling, appears to lessen the risk of depression. Conversely, moderate, vigorous recreational, and moderate recreational activities may increase their predisposition to depression. In contrast, the non-Hispanic Black population benefits from moderate recreational activities but seems to have an increased risk of depression when involved in moderate work activities and walking or cycling. Non-Hispanic Whites exhibit a markedly reduced risk of depression with moderate recreational activities, which

appear to act as protective factors. Other racial groups did not demonstrate a significant correlation between any form of physical activity and depression. Nonetheless, vigorous recreational activities could potentially offer protective benefits, although the statistical significance is marginal.

My study determined that, among all participants, those without depression engaged in physical activity for an average of 116.3 minutes more per week compared to their counterparts with depression. This observation aligns with findings by Pearce et al., suggesting that adults who meet the recommended physical activity duration are less prone to depression (Pearce et al., 2022). Choi et al. also explored the bidirectional relationships between physical activity and depression in adults, reinforcing our conclusion about the protective nature of physical activity against depression (Choi et al., 2019). Similarly, research by Emily R. Rutherford et al. established that individuals engaging in over 150 minutes of moderate to vigorous work activity per week are less likely to experience depression (Rutherford et al., 2022). Our findings also receive backing from a study by Mats Hallgren et al. on the relationships between various sedentary behaviors, physical activity, and depression. This research recommended substituting passive sedentary actions with mentally active sedentary behaviors or moderate-to-vigorous work activity to diminish the risk of depression in adults (Hallgren *et al.*, 2020). Concurrently, Marije Aan Het Rot et al. emphasized that adhering to the CDC's recommendation of at least 30 minutes of moderate-intensity physical activity on most days significantly alleviates depressive symptoms (Aan Het Rot et al., 2009).

Additionally, a study conducted by Su Zhang et al. delved into the connection between physical activity and depression in older adults. They highlighted an inverse relationship between engagement in physical activities and the onset of depressive symptoms, underscoring the benefits of exercise in reducing depression risks for this demographic (Zhang et al., 2021). Mercy Ngosa Mumba et al. undertook research on the same demographic and not only corroborated our findings but also emphasized that, for many older adults, physical activity is a more cost-effective approach to mitigating depression risks than medical treatments. This study also suggested potential variations in depression rates across different racial groups, a key focus of our research (Mumba et al., 2021). The therapeutic potential of physical activity in addressing depression is also grounded in science. As Aaron Kandola et al. determined, physical activity exerts its antidepressant effects through various biological and psychosocial mechanisms within the brain, forging a protective shield against depression (Kandola et al., 2019). A similar conclusion was drawn in research by Megan Teychenne et al., which underscored an inverse correlation between physical activity and depression (Teychenne et al., 2008). Andreas Ströhle's study resonated with our findings, suggesting that physical activities bolster resilience against depression in adults (Ströhle, 2009). Intriguingly, research by A. P. Bailey et al. indicated that young adults and adolescents with depression could benefit significantly from physical activity as a primary intervention, suggesting its therapeutic potential in alleviating their symptoms (Bailey et al., 2018).

While the aforementioned studies corroborate our findings, emphasizing the benefits of physical activity in reducing depression risks for adults, there remains a noticeable gap in research addressing the potential disparities across different racial groups. This avenue presents an opportunity for researchers to delve deeper, seeking to understand the nuances of how and why individuals from various racial backgrounds might exhibit differing susceptibilities to depression.

This study boasts several significant strengths. Primarily, the analysis is underpinned by a robust participant sample. The model adjustments ensure the comprehensive inclusion of pertinent covariates, aided by an exhaustive survey. The physical activity questionnaire, validated in prior studies(Lagerros et al., 2006), astutely differentiates between various types of physical activities (Lagerros et al., 2006). Furthermore, our subgroup analysis segmented by race/ethnicity offers granular insights into how diverse physical activity types might uniquely affect different racial groups.

However, the research paper has limitations. Firstly, participants' self-reporting

of their physical activities could introduce recall errors during questionnaire completion. Secondly, our depression outcomes, defined by these self-reported questionnaires, might be prone to underestimation. This is due to potential disparities in participants' interpretation of the questions, which could result in imprecise responses and, consequently, skewed final scores. Lastly, inherent limitations are tied to the NHANES database, which is based on a cross-sectional population survey. By design, NHANES can only determine associations between factors, not the causative mechanisms underlying them. As a result, this study cannot conclusively establish causality.

Conclusion

Our study investigates the protective role of physical activities in mitigating the risk of depression among adults. Distinctively, the differential impacts of various physical activity types on depression risk were evident across the four racial groups studied. While these insights are promising, the results should be approached with prudence due to the inherent limitations highlighted. Future research, ideally with a more diverse racial categorization and a more expansive sample, is imperative to comprehensively understand the nuanced interplay between race, physical activity, and depression risk. Such endeavors could inform targeted interventions for specific racial groups, optimizing both treatment and prevention strategies.

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