Physical Activity and Neuropsychological Functioning in Older Adults

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Abstract

Research has identified a positive relationship between physical activity and neuropsychological functioning across the lifespan. The present study further examined the relationship between physical activity, depression, anxiety, and cognitive functioning in community-dwelling older adults (ages 65–96) who completed an outpatient neuropsychological evaluation ($N = 526$). Psychometrically sound and validated measures were used to assess depression, anxiety, and cognitive functioning. Analyses of covariance (ANCOVA) were conducted to examine differences between individuals who reported regularly engaging in physical activity and those who did not, after adjusting for demographic variables (age, education, and gender). Results indicated that physical activity was associated with better scores on measures of depression, anxiety, and cognitive functioning. Effect sizes for total scores on all measures were large, but there was a sizeable range of effect sizes (from small to large) for various cognitive domains. Smallest effect sizes were observed for subtests measuring language skills and visuospatial abilities, whereas largest effect sizes were seen in processing speed and memory. Results suggest that engaging in physical activity may be a beneficial non-pharmacological intervention for older adults. These findings underscore the importance of integrating physical activity programs in community and healthcare settings to foster mental and cognitive health in older populations.

Keywords

physical activity, exercise, cognition, depression, anxiety, older adults

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Introduction

The world population is getting older, and it has become increasingly important to understand healthy aging, which is defined by the World Health Organization (WHO) as "the process of developing and maintaining the functional ability that enables wellbeing in older age," (Rudnicka et al., 2020). WHO defines active aging as ". . . the process of optimizing opportunities for health, participation, and security in order to enhance quality of life as people age" (World Health Organization [WHO], 2002). Recent census data indicates that the Baby Boomer generation will all be over the age of 65 by 2030 and will be expected to outnumber children for the first time in U.S. history by 2034. Additionally, adults over age 65 are projected to nearly double in the U.S. population from 2016 to 2060 to approximately 94.7 million (Vespa et al., 2018).

Concurrent with this increase, the number of individuals with various forms of cognitive impairment is also expected to grow. It has been estimated that over 50 million people worldwide were living with dementia in 2020, a number that is expected to double every

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20 years and reach 152 million by 2050 (Guerchet et al., 2020). Despite extensive research efforts on pharmacological interventions that are in progress (e.g., Van Dyck et al., 2023), effective and safe disease-modifying pharmacological treatments for cognitive decline are yet to be developed (Amanatkar et al., 2017). As a result, non-pharmacological approaches, such as lifestyle modifications, are being increasingly explored. Physical activities (including) have been examined for their potential effects on mental health conditions, such as anxiety, depression, and cognitive decline (Baumgart et al., 2015; de Oliveira et al., 2019).

Physical activity and exercise are two words that are often used interchangeably in published literature. Physical activity is the broader umbrella term which encompasses "any bodily movement produced by skeletal muscles that results in energy expenditure," (Caspersen et al., 1985). Physical exercise activity in contrast is a more specific term which refers to "a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness" (Caspersen et al., 1985).

Physical Activity and Depression

Engagement in physical activity is associated with lower depressive symptoms, improved cardiovascular health, cognitive function, and overall well-being in adults across the lifespan (Becofsky et al., 2015; Laird et al., 2023; Mammen & Faulkner, 2013). A negative dose-response association has been found between moderate to vigorous physical activity and the risk of depression. A variety of physical activities have been shown to alleviate depressive symptoms in older adults, including resistance band training (Jong et al., 2021), aerobic and flexibility exercises (Pérez-Sousa et al., 2020), and Pilates (Ravari et al., 2021). In a recent systematic review and meta-analysis, Miller et al. (2020) found that consistent implementation of an exercise program was an effective adjunctive antidepressant treatment for older adults.

These findings are especially important given recent evidence that antidepressant medications may be less efficacious in older patients (Haigh et al., 2018). While most studies reported significant effects of physical activity interventions in reducing depressive symptoms, some findings have been inconsistent. Eng and Reime (2014) found that exercise alleviates depression symptoms during acute and chronic stages of stroke recovery, though benefits were not retained if exercise was discontinued. Additionally, they found that higher intensity exercise protocols (in terms of more frequent, longer, and varied exercises) had significant findings while protocols of lower intensity did not produce significant effects. Therefore, published literature points to a complex and multifaceted relationship between physical activity and mental health in older adults, warranting further examination.

Physical Activity and Anxiety

Physical activity may have a protective effect against anxiety symptoms. Utilizing data from over 80,000 participants, McDowell et al. (2019) found that physical activity was associated with a significantly lower prevalence of anxiety disorders. Moreover, a recent meta-analysis by Yao et al. (2021) supported the effects of consistent, regular aerobic exercise on the mental health of older adults. Their review included 15 randomized controlled trials and concluded that aerobic exercise significantly benefited mental health of individuals aged 60 years and older. The study suggested that long-term, regular aerobic exercise, even at low frequency, is particularly effective for this demographic, with the effect being consistent regardless of the subject type and duration of the intervention.

There is growing (but still limited) evidence of the effects of physical activity as a treatment for anxiety, particularly in older adults (Bartley et al., 2013; Wegner et al., 2014). A sedentary lifestyle has been associated with the presence of anxiety in older adults (Aguiñaga et al., 2018; de Oliveira et al., 2019). Some published research has indicated the presence of a dose-response relationship between physical activity and mental health (Kandola et al., 2019). Additionally, Smith and Merwin (2021) suggested that physical activity, including aerobic and resistance exercise, showed promise as a therapeutic intervention for mental health disorders. However, these authors noted that individual responses to exercise vary greatly, sustained engagement is crucial for therapeutic benefits, and there is debate over the mechanisms of therapy. They advocated for future research differences to refine exercise-based treatments for mental health, which merits further examination of this area.

Physical Activity and Cognitive Functioning

Published research has demonstrated a positive relationship between physical activity and cognitive functioning (Baumgart et al., 2015; Geda et al., 2010; Ludyga et al., 2020; Northey et al., 2018; Öhman et al., 2014). Physical activity, particularly aerobic exercise, can have protective effects against factors implicated in accelerated aging and the development of dementia (Tyndall et al., 2018). Both aerobic and resistance training interventions can improve performance on various cognitive assessments compared to control interventions (Xu et al., 2023). Although some research has indicated that physical activity is linked with specific domains of cognitive functioning (e.g., executive functioning, attention, delayed recall, and verbal fluency; Barha et al., 2017; Öhman et al., 2014), other authors have suggested that effects of exercise on cognitive function are global, rather than domain-specific (e.g., Ludyga et al., 2020). These studies collectively suggest that physical exercise is associated with beneficial outcomes in cognitive function among older adults; however, additional research is needed to better understand which domains of cognitive functioning are more strongly associated with physical activity.

Rationale for the Present Study

Examination of the relationship between physical activity and neuropsychological function in older adults is important for informing effective interventions that may delay or slow down cognitive decline or alleviate psychiatric symptoms in this population. The aim of the present study was to further investigate the association between physical activity and a number of behavioral health outcomes (anxiety, depression, and cognitive functioning) in a sample of community-dwelling older adults. We hypothesized that individuals who reported regular physical activity would display lower levels of anxiety and depression, and higher scores on tests of cognitive functioning. Few studies to date have examined the role of physical activity across both psychiatric and cognitive domains in this population; therefore, comprehensive examinations of the role of physical activity in older adults across multiple areas of well-being in one sample is warranted.

Methods

Procedures

The study utilized a retrospective analysis of archival clinical data. All participants completed the Geriatric Depression Scale-Short Form (GDS-SF), the Beck Anxiety Inventory (BAI), the Mini-Mental Status Exam (MMSE), and the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), as part of a comprehensive neuropsychological assessment battery. The study was approved by the Human Subjects Ethics Review Committee (HSRC) at a local university. To reduce type I error due to multiple analyses, false discovery rate (FDR) (Benjamini & Hochberg, 1995) was utilized, correcting for multiple comparisons at $p < .05$.

Participants

This study involved a sample of 526 community-dwelling adults aged 65 to 96 who presented for an evaluation at an outpatient neuropsychological clinic in Coastal Virginia. The average age of participants in the data set was 76.43 (*SD*=6.70), and the average number of years of education completed was 13.97 (*SD*=4.08). Of 526 patients, 244 reported that they engage in physical activity on a regular basis, whereas 282 patients reported that they do not engage in regular physical activity. After checking in for their appointment, participants completed a history form in the waiting room. This form had several dichotomous questions on it regarding the patient's health. On this form patients were asked to indicate whether they regularly engaged in physical exercise. For the purposes of this study, engagement in physical activity was defined by whether or not the individuals endorsed that they engage in regular physical exercise on the history form. Patients circled "yes" or "no" in response to the question, "*Do you exercise on a regular basis*?" Responses were later reviewed and discussed in clinical interviews (completed by doctoral-level psychologists or a board-certified neuropsychologist) to obtain further information regarding habits. Although participants were responding to a question about exercise, they likely were not considering the nuanced difference between exercise and physical activity (e.g., structured and planned exercise vs. more general physical activity), as revealed by clinical interviews that followed the completion of the intake questionnaire. Therefore, participants' responses in fact represent both exercise and physical activity (which is a broader construct than exercise). This information was later used in the clinical report to provide treatment recommendations. Further information about the type, or length of engagement in physical activity was not available for the present study due to the limited time available for an intake interview in clinical settings. Complete demographic data for the sample population are represented in Table 1. An embedded performance validity test, the Effort Index (EI) within the RBANS (Silverberg et al., 2007) was utilized. Participants were included in the current study only if they produced a valid score on the EI (<3).

Table 1. Participant Demographics and Characteristics (*N*=526).

	n (%)
Gender	
Female	294 (55.9)
Male	232 (44.1)
Marital status	
Married	368 (69.9)
Widowed	80 (15.2)
Single	55 (10.5)
Divorced	23 (4.4)
Race/Ethnicity	
White	356 (67.7)
Black	90 (17.1)
Asian	8 (1.5)
Latinx	35 (6.7)
Other	37 (7.0)
Physical activity status	
Regular physical activity	244 (46.4)
No regular physical activity	282 (53.6)

Psychiatric Symptoms

Geriatric Depression Scale (GDS). Depression was assessed using the Geriatric Depression Scale-Short

Form (GDS-SF; Sheikh & Yesavage, 1986), a 15-item self-report measure containing a "yes" or "no" format, specifically designed for older adults to assess depressive symptoms. The GDS-SF is known for its high reliability and validity when used among older adult populations. Sheikh and Yesavage (1986) demonstrated that GDS-SF has excellent internal consistency, with Cronbach's alpha coefficients often exceeding .80, indicating good homogeneity among items. The GDS-SF has been shown to have high test-retest reliability, ensuring that the measure is stable over time, which is crucial for monitoring depressive symptoms in the older adults over longitudinal studies (Sheikh & Yesavage, 1986). The GDS-SF has been validated against the criteria for major depressive episodes as per the Diagnostic and Statistical Manual of Mental Disorders (DSM), showing strong sensitivity and specificity. The GDS-SF is scored by having examinees respond "yes" or "no" to each of its items. Each response is then assigned a score of 1 or 0 based on the scoring instructions, with specific items scored in reverse to account for positively phrased questions. The sum of these item scores yields the total score, reflecting the examinee's level of depression symptoms. Total GDS-SF score was used in the present study, with higher scores indicating greater symptoms of depression.

Beck Anxiety Inventory (BAI). Anxiety symptoms were assessed utilizing the Beck Anxiety Inventory (BAI; Beck et al., 1988), a 21-item self-report inventory that measures the severity of both somatic and cognitive symptoms of anxiety, asking respondents to rate how much they have been bothered by each symptom during the past week on a scale from 0 (not at all) to 3 (severely). The BAI has consistently demonstrated high internal consistency across various populations, with Cronbach's alpha coefficients often cited as .89 or above, indicating a strong degree of reliability among the items of the scale (Beck et al., 1988; Morin et al., 1999). Fydrich et al. (1992) found the test-retest reliability of the BAI to be satisfactory ($r = .67$), indicating that it produces stable scores over time. The BAI also has been shown to correlate highly with other measures of anxiety, such as the SCL-90 Anxiety Subscale (coefficients ranged between 0.78 and 0.81; Steer et al., 1993). Total BAI score was used in the present study, with higher scores indicating greater symptoms of anxiety.

Cognitive Functioning

Mini-Mental State Examination (MMSE). MMSE is a widely used and validated 30-point cognitive screening measure that includes a variety of cognitive tasks (Folstein et al., 1975). It consists of questions and tasks that cover different cognitive domains, such as orientation, attention, memory, language, visuo-spatial abilities, and constructional skills (Bernard & Goldman, 2010). The MMSE has demonstrated moderately high levels of reliability and internal consistency across diverse patient populations, including those with dementia and other psychiatric conditions, as well as cognitively intact individuals (Bernard & Goldman, 2010). Multiple reviews of the MMSE revealed satisfactory reliability and construct validity (Lopez et al., 2005; Tombaugh & McIntyre, 1992). Total MMSE score was used in the present study, with higher scores indicating better cognitive function.

Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). Additionally, the RBANS was administered to provide a more comprehensive assessment of cognitive functioning. The RBANS is an individually administered test intended to evaluate neuropsychological status of adults aged 20 to 89 years, particularly those with suspected neurological deficits (Randolph et al., 1998). It is utilized in clinical settings to provide co-normed measures of immediate memory, visuospatial/constructional skills, attention, language, and delayed memory and has been shown to be sensitive to mild cognitive impairment and dementia in older adults (Randolph et al., 1998). Research has supported the clinical value and psychometric properties of the RBANS across various medical populations (Loughan et al., 2019), and it has been shown to have adequate sensitivity in detecting cognitive impairments in various neuropsychiatric conditions (Duff et al., 2010). RBANS Total Scale Scores were used in the present study, along with all subtest scores. Higher scores indicate better cognitive functioning.

Statistical Analyses

All statistical analyses were completed using Statistical Package for the Social Sciences version 29 (SPSS). Analyses of covariance (ANCOVA) were conducted to examine differences between individuals who reported engaging in physical activity regularly and those who did not, after adjusting for demographic variables (age, education, and gender). Engagement in physical activity was the independent variable in each analysis. Dependent variables included the total scores for the GDS-SF, BAI, MMSE, and RBANS. The RBANS subtest scores were also used as dependent variables in follow-up analyses to evaluate differences in specific domains of cognitive functioning based on physical activity status. Finally, hierarchical regression analyses were completed with GDS-SF, BAI, MMSE, and RBANS total scores as outcome variables, and demographic variables (age, education, and gender) entered as predictors at the first step. Physical activity variable was added at the second step to ascertain the unique variance it would explain in the outcome variables beyond demographics. Only individuals aged 65 or older and who had completed all assessments mentioned above were included in this study. To ensure the quality of the data, participants were only included if

Table 2. Comparing Means and Standard Deviations for Outcome Variables Between Physical Activity Group and Control Group ($N = 526$).

	Physical activity group ($n = 244$)		Control group ($n = 282$)			
	M	*SD*	*M*	*SD*	*p*	Effect size partial η^2
Psychiatric symptoms						
Anxiety (BAI)	3.54	5.57	10.31	11.97	<.001	0.10
Depression (GDS-SF)	2.70	2.96	5.46	4.68	<.001	0.10
Cognitive functioning						
MMSE	26.76	2.79	23.32	4.48	<.001	0.15
RBANS						
Total scale score	99.54	19.43	80.58	21.81	<.001	0.14
List learning	19.32	5.73	15.67	5.66	<.001	0.07
Story memory	12.73	4.71	9.74	4.76	<.001	0.06
Figure copy	17.25	2.70	15.87	3.38	<.001	0.04
Line orientation	15.01	3.73	12.66	4.80	<.001	0.04
Picture naming	9.49	0.80	9.01	1.54	<.001	0.02
Semantic fluency	15.48	4.96	12.23	4.98	<.001	0.07
Digit span	9.50	2.35	9.14	2.94	.348	0.00
Coding	32.28	10.60	23.78	12.18	<.001	0.09
List recall	1.99	2.42	1.01	2.00	<.001	0.03
List recognition	17.26	2.69	15.49	3.48	<.001	0.06
Story recall	5.62	3.30	3.23	3.02	<.001	0.10
Figure recall	8.30	5.88	4.56	5.14	<.001	0.09

Note. All differences were statistically significant after False Discovery Rate (FDR) correction for multiple comparisons, with the exception of Digit Span. *M* = mean; *SD* = standard deviation; effect size is represented by partial eta squared (η^2); BAI = Beck anxiety inventory; GDS-SF = Geriatric Depression Scale, short form; MMSE = mini-mental state examination; RBANS = repeatable battery for the assessment of neuropsychological status.

they produced a valid score on the performance validity measure. This left 526 individuals available for the final analysis. Data were normally distributed and met requirements for the statistical analyses utilized.

Results

First, the two groups of participants (those who engage in regular physical activity and those who did not) were compared in terms of demographic characteristics. It was found that participants who reported physical activity as part of their regular lifestyle were on average 1.41 years younger ($M_{age} = 75.67$, $SD = 6.29$, range 65–88) than those who did not regularly engage in physical activity ($M_{age} = 77.08$, $SD = 6.97$, range 65–96). This difference was statistically significant ($p = .016$). Significant differences were also found between the two groups in terms of education, with the physical activity group reporting on average a higher number of completed years of education ($M = 14.88$, $SD = 4.89$), compared to the control group ($M = 13.18$, $SD = 3.01$). No statistically significant differences were found between the two groups in term of gender ($\chi^2 = 0.004$, $p = .94$).

Analyses of Covariance (ANCOVA)

Next, analyses of covariance (ANCOVA) were conducted to compare the two groups ("physical activity" and "no physical activity") in terms of cognitive functioning and psychiatric symptoms, after adjusting for demographic variables (age, education, and gender). ANCOVA results revealed that the physical activity group displayed better scores on measures of depression (GDS $M = 2.70$, $SD = 2.96$), anxiety (BAI $M = 3.54$, $SD = 5.57$), and cognitive functioning (MMSE, $M = 26.76$, $SD = 2.79$; RBANS, $M = 99.54$; $SD = 19.43$), as compared to the group that did not report engaging in regular physical activity (GDS, $M = 5.46$, $SD = 4.68$; BAI, $M = 10.31$, $SD = 11.97$; MMSE, $M = 23.32$, $SD = 4.48$; RBANS, $M = 80.58$, $SD = 21.81$). All differences were statistically significant at $p < .001$ after the FDR correction for multiple comparisons, with the exception of Digit Span ($p = .348$). Effect sizes ranged from small to large (partial η^2: 0.02–0.15). Comprehensive details of these statistical analyses can be found in Table 2 and in Figures 1 to 3.

Hierarchical Multiple Regressions

Finally, follow-up hierarchical regression analyses were conducted to evaluate the magnitude of the relationship between physical activity and all outcome variables, after adjusting for demographic factors (age, education, and gender). The outcome variables were divided into two categories: psychiatric symptoms (anxiety and depression) and cognitive functioning (total scores on the

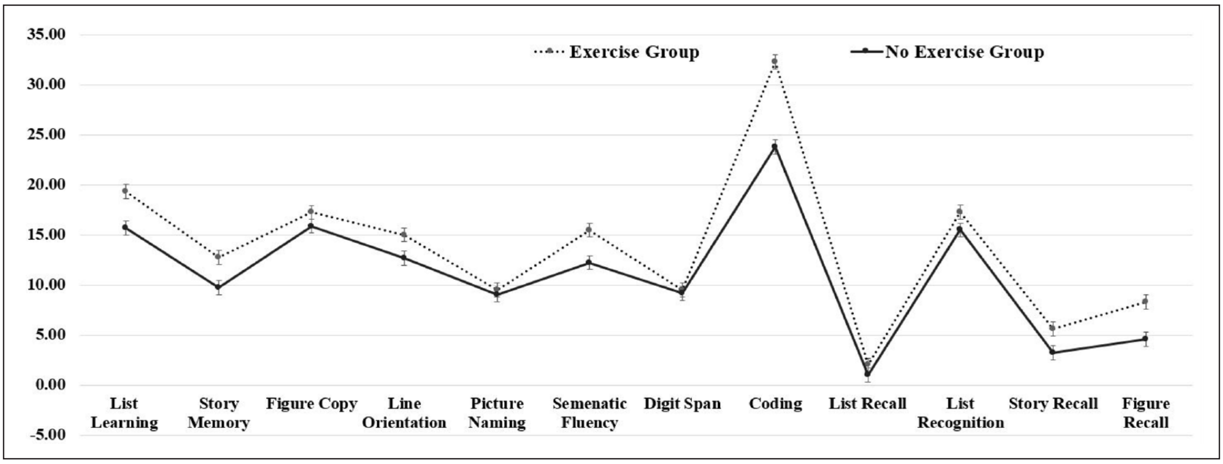

Figure 1. Differences in RBANS subtests raw scores between physical activity group and control group.
Note. Higher scores indicate better performance. Participants who reported regularly engaging in physical activity performed significantly better on most RBANS subtests (with the exception of Digit Span) compared to those who did not report regular physical activity. RBANS = repeatable battery for the assessment of neuropsychological status.

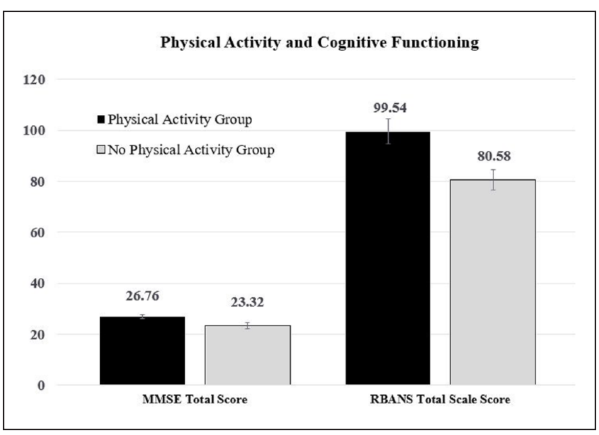

Figure 2. Differences in MMSE total scores and RBANS total scaled scores between physical activity group and control group.
Note. Higher scores indicate better cognitive functioning. Participants who reported regularly engaging in physical activity displayed significantly better total scores on both measures of cognitive functioning: MMSE and RBANS. Differences were statistically significant ($p < .001$) after False Discovery Rate (FDR) correction for multiple comparisons. MMSE = mini-mental state examination; RBANS = repeatable battery for the assessment of neuropsychological status.

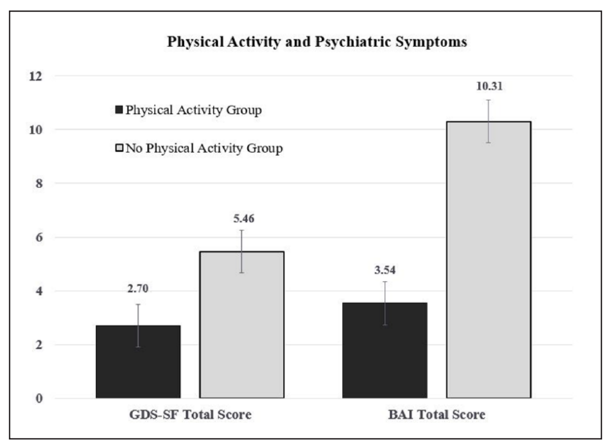

Figure 3. Differences in Psychiatric Symptoms Between Physical Activity Group and Control Group.
Note. Higher scores indicate higher levels of psychiatric symptoms. Participants who reported regularly engaging in physical activity displayed significantly lower scores on measures of depression (GDS-SF) and anxiety (BAI). Differences were statistically significant ($p < .001$) after False Discovery Rate (FDR) correction for multiple comparisons. GDS-SF = Geriatric Depression Scale, short form; BAI = Beck anxiety inventory.

MMSE and the RBANS). Complete details of hierarchical regression analyses are presented in Table 3 (psychiatric symptoms) and Table 4 (cognitive functioning).

In the first set of analyses focusing on psychiatric symptoms, the initial model (Model 1) that included only demographic variables, accounted for a small but significant portion of variance in both anxiety ($R^2 = .023$, $F(3, 522) = 4.15$, $p = .006$) and depression ($R^2 = .018$, $F(3, 522) = 3.12$, $p = .026$). Within this model, the level of education was a significant predictor for both anxiety ($\beta = -.15$, $p < .001$) and depression ($\beta = -.11$, $p = .011$), while gender and age were not significant predictors. Adding physical activity at the next step (Model 2) as an additional predictor significantly increased the explained variance in both anxiety ($\Delta R^2 = 0.096$, $F(4, 521) = 17.70$, $p < .001$) and depression ($\Delta R^2 = 0.097$, $F(4, 521) = 16.83$, $p < .001$). This suggests that physical activity habits contribute to psychiatric symptoms above and beyond the demographic factors, with physical activity being significantly associated with lower levels of both anxiety and depression.

The analyses regarding cognitive functioning revealed that demographic variables alone (Model 1) explained a considerable amount of variance in MMSE scores ($R^2 = 0.059$, $F(3, 522) = 10.96$, $p < .001$) and in RBANS scores ($R^2 = 0.173$, $F(3, 522) = 36.28$, $p < .001$). In these models, both age and education were significant

Table 3. Hierarchical Regressions Evaluating Associations of Physical Activity with Psychiatric Symptoms, After Adjusting for Demographic Characteristics ($N = 526$).

Hierarchical regression model	Omnibus model				Parameter estimates						
	R^2	*p*	ΔR^2	ΔR^2 sig	B	*SE* B	β	*t*	*p*	LLCI	ULCI
Outcome variable: Anxiety symptoms (BAI total score)											
Model 1	**.023**	**.006**	**—**	**—**							
Age					0.01	0.07	.01	0.15	.882	–0.12	0.14
Education					**–0.38**	**0.11**	**–.15**	**–3.50**	**<.001**	**–0.59**	**–0.17**
Gender					0.34	0.90	.02	0.38	.705	–1.42	2.10
Model 2	**.120**	**<.001**	**0.096**	**<.001**							
Age					–0.04	0.06	–.03	–0.69	.489	–0.17	0.08
Education					–0.21	0.10	–.08	–2.01	.045	–0.42	0.00
Gender					0.25	0.85	.01	0.29	.769	–1.42	1.92
Physical activity					**–6.48**	**0.86**	**–.32**	**–7.55**	**<.001**	**–8.16**	**–4.79**
Outcome variable: Depression symptoms (GDS–SF total score)											
Model 1	**.018**	**.026**	**—**	**—**							
Age					0.02	0.03	.03	0.57	.566	–0.04	0.07
Education					**–0.11**	**0.04**	**–.11**	**–2.54**	**.011**	**–0.20**	**–0.03**
Gender					0.62	0.37	.07	1.65	.099	–0.12	1.35
Model 2	**.114**	**<.001**	**0.097**	<.001							
Age					–0.01	0.03	–.01	–0.25	.805	–0.06	0.05
Education					–0.04	0.04	–.04	–1.02	.307	–0.13	0.04
Gender					0.58	0.35	.07	1.63	.103	–0.12	1.28
Physical activity					**–2.70**	**0.36**	**–.32**	**–7.55**	**<.001**	**–3.40**	**–1.99**

Note. Bold font indicates statistical significance after adjustment for familywise error using False Discovery Rate (FDR). R^2 = coefficient of determination; ΔR^2 = change in R^2 when additional predictors are added; ΔR^2 sig = *p*-value for change in R^2; B = unstandardized beta; *SE*B = standard error of beta; β = standardized beta coefficient; LLCI = lower limit confidence interval; ULCI = upper limit confidence interval; BAI = Beck anxiety inventory; GDS-SF = Geriatric Depression Scale, short form.

Table 4. Hierarchical Regressions Evaluating Associations of Physical Activity with Cognitive Functioning, After Adjusting for Demographic Characteristics ($N = 526$).

Hierarchical regression model	Omnibus model				Parameter estimates						
	R^2	*p*	ΔR^2	ΔR^2 sig	B	*SE* B	β	*t*	*p*	LLCI	ULCI
Outcome variable: MMSE total score											
Model 1	**.059**	**<.001**	**—**	—							
Age					**–0.11**	**0.03**	**–.17**	**–3.94**	**<.001**	**–0.16**	**–0.05**
Education					**0.18**	**0.04**	**.18**	**4.20**	**<.001**	**0.10**	**0.27**
Gender					–0.41	0.36	–0.05	–1.13	.261	–1.12	0.30
Model 2	**.195**	**<.001**	**0.136**	**<.001**							
Age					**–0.08**	**0.02**	**–.13**	**–3.17**	**.002**	**–0.13**	**–0.03**
Education					**0.10**	**0.04**	**.10**	**2.46**	**.014**	**0.02**	**0.18**
Gender					–0.36	0.33	–.04	–1.09	.278	–1.02	0.29
Physical activity					**3.16**	**0.34**	**.38**	**9.39**	**<.001**	**2.50**	**3.82**
Outcome variable: RBANS total scale score											
Model 1	**.173**	**<.001**	**—**	**—**							
Age					**–1.11**	**0.14**	**–.33**	**–8.04**	**<.001**	**–1.38**	**–0.84**
Education					**1.49**	**0.22**	**.27**	**6.71**	**<.001**	**1.06**	**1.93**
Gender					–4.14	1.86	–0.09	–2.23	.026	–7.78	–0.49
Model 2	**.285**	**<.001**	**0.112**	<0.001							
Age					**–0.98**	**0.13**	**–0.29**	**–7.57**	**<.001**	**–1.23**	**–0.72**
Education					**1.09**	**0.21**	**.20**	**5.14**	**<.001**	**0.67**	**1.50**
Gender					–3.92	1.73	–0.09	–2.27	.024	–7.31	–0.53
Physical activity					**15.74**	**1.74**	**.35**	**9.05**	**<.001**	**12.32**	**19.16**

Note. Bold font indicates statistical significance after adjustment for familywise error using False Discovery Rate (FDR). R^2 = coefficient of determination; ΔR^2 = change in R^2 when additional predictors are added; ΔR^2 sig = *p*-value for change in R^2; B = unstandardized beta; *SE*B = standard error of beta; β = standardized beta coefficient; LLCI = lower limit confidence interval; ULCI = upper limit confidence interval; MMSE = mini-mental state examination; RBANS = repeatable battery for the assessment of neuropsychological status.

predictors of cognitive performance, while gender was not. Specifically, age ($\beta = -.17$, $p < .001$) and education ($\beta = .18$, $p < .001$) were significantly associated with MMSE scores, and similarly, age ($\beta = -.33$, $p < .001$) and education ($\beta = .27$, $p < .001$) were significantly related to RBANS scores. Introducing physical activity as an additional predictor at the next step (Model 2) significantly enhanced the models, explaining additional 13.6% of variance in MMSE scores ($\Delta R^2 = 0.136$, $F(4, 521) = 31.62$, $p < .001$) and 11.2% of variance in RBANS scores ($\Delta R^2 = .112$, $F(4, 521) = 51.89$, $p < .001$). These findings underscore the significant positive relationship between physical activity and cognitive functioning beyond demographic factors.

In summary, findings revealed a significant association between physical activity and both psychiatric symptoms and cognitive functions, indicating that regular physical activity contributes uniquely to mental health and cognitive performance beyond the influence of demographic characteristics.

Discussion

The findings of the current study have revealed significant associations among physical activity, psychiatric symptoms, and cognitive functioning in older adults. Participants who reported regularly engaging in physical activity exhibited significantly lower levels of depression and anxiety compared to those who did not. These results are consistent with existing literature that consistently reports a positive correlation between physical activity and lower levels of psychiatric concerns in older adult populations (e.g., Laird et al., 2023; Mammen & Faulkner, 2013; McDowell et al., 2019; Miller et al., 2020). The observed inverse relationship between regular physical activity and the prevalence of depression and anxiety symptoms among older adults may be attributed to both biological and psychosocial mechanisms. Biologically, physical activity has been shown to promote neuroplasticity, enhance the release of neurotrophic factors such as brain-derived neurotrophic factor (BDNF), and modulate the hypothalamic-pituitary-adrenal (HPA) axis, thereby contributing to improved mood and reduced stress responses (Heijnen et al., 2015; Mikkelsen et al., 2017). Psychosocially, engaging in physical activity often provides increased opportunities for social interaction and fosters a sense of community and belonging, which are crucial for mental health and well-being in later life (Lindsay Smith et al., 2017). Moreover, the sense of accomplishment and the improvements in self-esteem and self-efficacy associated with regular physical activity can further contribute to the alleviation of psychiatric symptoms (Park et al., 2014).

Furthermore, a significant relationship was found between physical activity and cognitive functioning, as indicated by higher MMSE and RBANS scores among those who reported regularly engaging in physical activity. These findings are also generally in line with extant research (e.g., Baumgart et al., 2015; Ludyga et al., 2020; Xu et al., 2023). These studies collectively highlight the critical role of an active lifestyle in maintaining healthy cognitive function across the lifespan. Our findings contribute to this growing body of evidence, reinforcing the need for public health strategies that promote physical activity as a means to preserve cognitive health and potentially even prevent cognitive decline (Omura et al., 2020).

It should be noted that the effect size for differences in cognitive performance on total scores for both measures was large. Specifically, the difference in the MMSE total scores between the two groups was approximately 1.23 standard deviations, and average MMSE score for the control group was 23.32 (below the cut-off < 24; Spering et al., 2012), suggesting potential cognitive impairment. Similarly, the difference in the RBANS total scale scores between the two groups was 18.96 points (1.26 standard deviations), and the mean RBANS total scale score in the control group was 80.58, which is approximately 1.3 standard deviations below the normative mean, indicating potential presence of a mild neurocognitive disorder in this group (according to the DSM-5 guidelines). Cognitive scores for the physical activity group on both measures were within the average range. These results suggest that lack of physical activity may be associated with an increased risk of cognitive decline in older adults, which is consistent with previously published studies (e.g., Cai et al., 2023).

Regarding specific cognitive domains, subtests assessing language skills and visuospatial abilities yielded the smallest effect sizes, suggesting a more modest benefit from physical activity in these areas. In contrast, the most pronounced differences were observed in domains related to processing speed and memory, where individuals engaging in regular physical activity demonstrated stronger performance. This suggests that physical activity might facilitate more efficient mental processing, enabling quicker assimilation and response to information (Liu-Ambrose et al., 2021; Nouchi et al., 2014). Similarly, memory-related tasks (such as immediate verbal learning, delayed story and figure recall, as well delayed list recognition) had medium to large effect sizes. These findings indicate that regular physical activity may bolster the capacity for both the acquisition of new information and the retrieval of stored information, which could be explained by increased hippocampal functional connectivity associated with physical activity (Won et al., 2021).

Physical activity is posited to have protective effects against psychiatric symptoms and cognitive decline through multiple biological and psychosocial mechanisms. One primary biological pathway involves the upregulation of neurotrophic factors, notably brain-derived neurotrophic factor (BDNF), which plays a critical role in neuronal survival, neuronal development, and synaptic plasticity (Chia & Marino, 2023). Furthermore, physical activity has been implicated in the stimulation of neurogenesis, particularly in the hippocampal region, which is integral to memory and learning (Pahlavani, 2023). The anti-inflammatory effects of regular physical activity may also be beneficial, as neuroinflammation is a common feature in both cognitive impairment and psychiatric disorders (Farrukh et al., 2023).

Additionally, physical activity can modulate the hypothalamic-pituitary-adrenal (HPA) axis, reducing the impact of stress on the body and mind (Athanasiou et al., 2022). This modulation may decrease the prevalence of anxiety and depressive symptoms by altering the body's response to stress. The endorphin hypothesis suggests that exercise induces the release of endogenous opioids, which can improve mood states (Chen & Nakagawa, 2023). Improvements in cerebral blood flow through aerobic exercise may further support cognitive functions by enhancing oxygen and nutrient delivery to the brain (Kwok et al., 2023). Moreover, regular engagement in moderate-intensity physical activity for the older adult population is associated with better sleep quality, which is closely linked to both cognitive and psychological health (Zhao et al., 2023).

Differences in Demographic Factors

In examining the age-related differences between the physical activity and no-physical activity groups in our study, we found that the physical activity group ranged from 65 to 88 years and the control group from 65 to 96. This suggests that physical activity levels may decline with advancing age, which has been suggested in extant research (e.g., Rantakokko et al., 2013; Valenzuela et al., 2019). This trend could be attributed to several factors. For example, increased physical limitations and health concerns may hinder the ability to engage in physical activity. Lifestyle changes, such as retirement and alterations in social networks, can also contribute to more sedentary behaviors (Lindsay Smith et al., 2017). Additionally, safety concerns regarding the risk of injury or falls may deter some older adults from exercising, given the increased susceptibility to mobility decline (Rantakokko et al., 2013). Lastly, the challenge of accessing suitable and enjoyable physical activities tailored to the needs of older adults may also be a significant barrier. The presence of individuals up to 96 years old in the control group, as opposed to the 88-year upper limit in the physical activity group, suggests that the oldest segments of the population may be less likely to engage in regular physical activity. This observation underscores the necessity for targeted interventions and programs designed to overcome the barriers to physical activity among older adults, thereby promoting health and well-being in this population.

The observed difference in educational attainment between the physical activity and no-physical activity groups could be attributed to several factors including socio-economic status, lifestyle choices, and accessibility to resources. For example, individuals with higher levels of education may be more exposed to health-related information and may be more aware of the benefits of physical activity on cognitive and overall health. Additionally, higher educational attainment is frequently associated with better socio-economic status, which often translates into greater access to recreational facilities and resources conducive to regular physical activity, such as gyms, sports clubs, and safe outdoor spaces for physical activity. In fact, previously published research has demonstrated a significant association between physical activity and socio-economic status (Stalling et al., 2022).

Clinical Implications

The robust findings of the current study combined with validated results from previous studies (e.g., Baumgart et al., 2015; Geda et al., 2010; Ludyga et al., 2020; Miller et al., 2020; Northey et al., 2018; Öhman et al., 2014) confirm that physical activity may be neuroprotective. Given the positive psychological and cognitive implications for aging adults, there is both value and necessity in incorporating movement into clinical care. This can be done through psychoeducation, improving accessibility, and social support.

Healthcare providers can educate patients about the recommended 150 min of weekly moderate physical activity (American Heart Association, 2023) and then explore what types of movement patients enjoy, such as aerobic, strength, or mind-body oriented. Because many types of exercise can have demonstrated benefits (Jong et al., 2021; Pérez-Sousa et al., 2020; Ravari et al., 2021), individuals can feel empowered to choose what they like and receive positive physical, emotional, and neurocognitive effects.

Making movement accessible is another important aspect in helping patients engage in more physical activity. Digitally delivered at-home workouts can make exercising more convenient and manageable (Aguiñaga et al., 2018). Additionally, movement modifications can help older adults engage in exercise more comfortably. For example, low impact exercises, such as aqua aerobics (Farinha et al., 2021), or chair-based movements (Efendi et al., 2023), are accommodating to joint pain or restricted mobility.

Another way to integrate movement into clinical care is the engagement of patient's support system. For example, healthcare providers may encourage walking when a patient is meeting with friends or relatives, or incorporate walking into regularly scheduled appointments (Koziel et al., 2022). Family participation could also be encouraged in the patient's movement-based care plan. When movement is incorporated into socializing with loved ones, patients may benefit not only from improved psychiatric symptoms and cognitive functioning, but also from the psychosocial benefits of connection to others (Komatsu et al., 2017).

Limitations and Directions for Future Research

The present study is subject to several limitations. The cross-sectional design restricts the ability to infer causality between physical activity and the improvements in depression, anxiety, and cognitive function. Additionally, self-reported data on physical activity levels may not accurately reflect the actual physical activity patterns due to reporting bias. Information on the type of physical activity (as well as frequency and intensity), was not available in the dataset. As such the analyses were limited to a single variable of self-reported engagement in regular exercise (and this group included individuals who regularly engaged in general physical activity and/or in structured exercise). The sample, drawn exclusively from community-dwelling older adults in the Coastal Virginia region, may not be representative of other populations (e.g., those dwelling in nursing homes or assisted living communities), limiting the generalizability of the findings. Additionally, potential confounding variables that may influence both physical activity and mental health outcomes were not exhaustively controlled for, and the sensitivity of the measurement tools may not fully capture the complexity of the constructs being assessed. Future research may focus on longitudinal designs to better understand the causal relationships between physical activity and mental health outcomes. Implementing randomized controlled trials could elucidate the efficacy of specific physical activity interventions on psychological and cognitive health in aging adults. More comprehensive and objective measures of physical activity, such as the use of wearable technology, could provide a more accurate assessment of physical activity patterns. Expanding research to encompass a wider demographic, including varied geographic locations and culturally diverse populations, would also enhance the external validity of the findings.

Conclusion

In conclusion, the present study investigated the differences in psychological well-being and cognitive functioning between older adults who reported exercising on a regular basis and those who did not. The findings indicate that regular physical activity is associated with significantly lower levels of depression and anxiety and improved cognitive performance. Analyses also revealed demographic differences between the two groups, with the physical activity group being slightly younger. The oldest participant in the physical activity group was 88 years old, compared to 96 years in the no-physical activity group. Furthermore, a significant negative correlation was found between physical activity participation and education level (individuals who regularly engaged in physical activity had higher levels of education). This relationship may reflect an association between socioeconomic status and physical activity engagement. However, hierarchical regression analyses demonstrated that the associations between physical activity and both psychiatric symptoms, as well as cognitive functioning, remained significant after adjusting for demographic variables such as age, gender, and education.

Overall, results of the present study underscore the potential of physical activity as a valuable non-pharmacological intervention for reducing psychiatric symptoms and improving cognition in older adults. Tailored physical activity programs that consider the specific needs and limitations of this demographic could serve as effective components of holistic mental health strategies, potentially reducing the reliance on pharmacotherapy and its associated side effects. Future research should explore the optimal types and intensities of physical activity that maximize mental health benefits for older adults, facilitating the development of targeted, evidence-based interventions. The integration of physical activity programs into community and healthcare settings may offer a viable strategy to foster mental and cognitive health in older adults.

Declaration of Conflicting Interests

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