

Relationship among physical activity, cognitive function, depression and sedentary behavior in older adults

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Abstract: Ageing is defined as a marked and progressive loss of normal body functions that progress until death. Depression and age-related cognitive function decline affect older adults' quality of life. Recent years, physical activity (PA) has been proposed as an alternative and promising intervention for this age group. The purpose of the present study was to examine the relationship among PA, cognitive function, education level, depression symptoms, and sedentary behavior (SB) in older adults. Seventy-four (74) people volunteered to participate in the study aged 65 years and over. The participants were asked to respond to the following questionnaires: Geriatric Depression Scale (GDS-15), Mini-Mental State Examination (MMSE), International Physical Activity Questionnaire (IPAQ). Binary logistic regression analysis indicated that participants with moderate to vigorous level of PA revealed reduced odds of depressive symptoms ($OR = 3.224$, $p = 0.048$) and cognitive impairment ($OR = 0.333$, $p = 0.029$). In addition, higher educational level related to lower probability of cognitive decline ($OR = 0.269$, $p = 0.004$). SB was not found to be associated with cognitive function and depression. The results suggest the importance of regular PA in maintaining cognitive and psychological health in older adults throughout their lifetime.

Key words: physical activity, depression, education, cognitive function, sedentary behavior

Ageing is defined as "a progressive, generalized impairment of function resulting in a loss of adaptive response to stress and in a growing risk of age-related disease, the loss of adaptability giving rise to increased frailty and the probability of death" [42]. In 2013, according to the United Nations, there were 841 million people in the world aged 60 or above, a figure that is expected to rise to 2 billion by 2050 [53]. In 2007, among 201 countries, Greece had the 8th highest rate (24.5%) of people aged 60 years or over and by 2050 it's estimated to be in 4th place (41.6%) [58].

Chronic disease conditions, associated with ageing (e.g. cardiovascular diseases, hypertension, arthritis, Alzheimer's disease) cause a decline in the functional capacity and in the quality of life of older people [34]. Cognitive changes affect their lives by decline a wide range of cognitive abilities such as memory, decision making, processing speed, executive function, etc. [22], [24]. However, healthy elderly with high level of education continue to have high cognitive functioning as they get older. Also, studies have reported that high education level may delay a neurodegenerative pathology manifestation [29]. In addition, based on recent data, more than 20% of the elderly suffer from a mental or neurological disorder. Depression is the most common mental disorder in this age group, affecting 7% of the world's older population [57] and tends to increase with age [38]. Depression symptoms often co-exist with other problems experienced by older people and as a result are overlooked and not treated in a timely manner [59].

Despite the biological, psychological and social impairments experienced by older people, there are interventions which can have a positive impact on their quality of life. PA is an important non-pharmacological intervention to prevent and to manage the chronic disease conditions that occur with increasing age, as it promotes social participation and independence [1], [13]. It has been shown that people who exercise regularly tend to have better quality of life and life expectancy [9]. Specifically, participation of older adults in PA intervention programs is associated with a low risk of mortality from coronary heart disease, stroke, hypertension, type 2 diabetes and cancer. Additionally, in recent years, it has been supported that PA and exercise protect against depression and also reduce the symptoms in older adults [10], [47]. The UK's guideline of the Institute for Health and Care Excellence (NICE) suggests moderate intensity aerobic group exercise for improve depression symptoms in adults (subthreshold, mild, moderate, severe depression) [36].

The World Health Organization (WHO) released a report referring to PA recommendations for preventing and managing noncommunicable diseases, cognitive decline and symptoms of depression and anxiety in older adults. The WHO report sets a target of performing a moderate- intensity aerobic PA of 150 minutes per week or vigorous- intensity aerobic PA of at least 75 minutes or a combination of moderate and vigorous intensity PA throughout the week. Also, it recommends the exercise program to include balance and strengthening exercises which should be performed two or more times a week [58]. Despite the significant impact of PA in the improvement of quality of life in older people, sedentary behavior (SB) is highly increased globally and has been reported to be one of the leading causes of death in developed countries (WHO, 2018). SB

is defined as any waking behavior in a sitting, reclining or standing posture characterized by low energy expenditure (≤ 1.5 METS) [53]. Research studies suggest that regardless of PA levels, SB is associated with an increased risk of cardiometabolic disease [11].

Older adults spend most of their daytime sitting or lying. According to Harvey, Chastin, and Skelton (2013) review, almost 60% of older adults reported (subjective measurement) sedentary activities for more than 4 hours per day, while 67% of the population was found to be sedentary (TV, computer) for more than 8.5 hours per day (objective measurement) [23]. In the USA, people aged 60 years or over are mainly these that revealed the most sedentary lifestyle and spend 60% of the day in sedentary activities [36]. In European countries, the percentage of adults with SB between 2002 and 2017 increased by 23.1% in Austria, 15.3% in Greece, 13.3% in Portugal and 3.1% in Germany [31].

The aim of the present study was to examine the relationship among PA levels, cognitive function, education, depression and SB in older adults. Based on previous evidence, we hypothesized that higher PA levels would be positively related to lower depressive symptoms and to higher cognitive functions in older adults. In addition, we hypothesized that time spent in sedentary behavior would be positively associated with depressive symptoms. Furthermore, we assumed that elderly persons with higher education level would succeed higher score in cognitive tests.

Method

Participants

The study sample consisted of seventy-four community dwelling older people who visited the Open Care Centres for the Elderly (OCCE) for a general cognitive and mental assessment. Inclusion criteria were: (1) age ≥ 65 , (2) being able to communicate and to understand the instructions for the questionnaires. Exclusion criteria were: Inability to understand the assessment protocol of the study.

Measures

Physical activity level. The International Physical Activity Questionnaire (IPAQ) [40] has been used to examine the participants' level of physical activity. The IPAQ consists of 7 open-ended questions that estimate the time spent by the participant during the last week in vigorous and moderate intensity activities, walking as well as sedentary occupations. The PA level is calculated by multiplying days per week, minutes per day and energy requirements (MET) of the corresponding activities. Based on the IPAQ scoring procedure, people's PA level is classified into three categories: (a) high (vigorous PA, at least 3 days/week and at least 1500 MET-min/week, 7 or more days of any combination of walking with moderate or high intensity to achieve a minimum threshold of 3000 MET-min/week), (b) moderate (3 or more days of vigorous PA of at least 20 min/day, 5 or more days of moderate intensity activity and/or walking of at least 30 min/day, 5 or more days of any combination of moderate intensity or vigorous intensity activities, or walking achieving a minimum of at least 600 MET/min, per week) and (c) low, the above criteria are not met. Due to the small number of participants with a high level of PA level in the present study, the participants were divided into two groups: (a) low PA and (b) moderate to high PA. In order to evaluate the SB, participants were asked to indicate how many daily hours they spend sitting. The participants of less than 7 hours/day of SB constitute the 1st group, whereas the participants of more than 7 hours/day of SB comprised the 2nd group. The variable was used as a categorical variable (0-7h, > 7h/day). The Cutoff criterion of 7 hours/days of SB was based on previous research findings [26].

Depression. The Geriatric Depression Scale-Short Form (GDS-SF) was used to examine participants' depressive symptoms. The GDS-SF is an internationally used instrument for the assessment of depression in geriatric population (Nadal et al., 2018), which has been translated and validated into Greek language [18]. Total scores between 0 and 5 indicate the absence of depressive symptoms, score between 6 and 10 indicate a moderate severity of depression and a score between 11 and 15 indicate severe depression. Due to the small number of participants with severe depression, in the present study depression received two levels: (a) absence of depression, and (b) depression.

Cognitive functions. The Mini Mental State Examination (MMSE) [17], [19] was used to evaluate the cognitive mental status of the elderly. The MMSE is a reliable, valid, and easy to handle test that consists of two parts. The first part evaluates orientation, memory, and concentration, receiving a maximum score of 21. The second part assesses comprehension, named recognition, which refers to the ability to follow simple verbal and written commands, obtaining a maximum score of 9. The Fountoulakis et al (2000) supported the validity and reliability into Greek population. A total score of 23/24 in the MMSE indicates absence of cognitive deficit, while a lower score indicates cognitive impairment.

Procedure

The selected questionnaires were completed with the assistance of the researcher in Open Care Centres for the Elderly (OCCE). Participants completed the three instruments in a single 30-minute session.

Statistical Analysis

Descriptive statistics were used for presentation of the patient characteristics and study variables. Quantitative continuous data are described by mean (M) and standard deviation (SD), and categorical variables are expressed as absolute (n) and relative frequencies (%) values. Spearman's correlation coefficient (rho) was used to evaluate the relationship between PA, cognitive function, depression, SB and education. Furthermore, a binary logistic regression was used to examine the predictive validity of PA level, education level, and SB on cognitive function and depression symptoms.

Statistical analysis was performed using the SPSS 25 statistical program. All statistical tests were two-sided, and conducted at the level of statistical significance, $p \leq 0.05$.

Results

Table 1 summarizes the socio-demographic characteristics of the participants. Seventy-four participants (81.1% men, 18.9% women) ranging in age from 65 to 99 years old ($M = 80.80$ years, $SD = 7.643$) volunteered to fill in the questionnaires of the study. Participants tended to have a low level of PA (51.4%) and their sedentary habits ranged from 0 to 7 hours per day (77.0%). In terms of educational level, more than half had received primary education (54.1%), while a smaller proportion had graduated from higher education (5.4%). In terms of depression, the majority of individuals had no symptoms (75.7%) and in terms of gender, a higher proportion of women had depression symptoms than men (50% vs. 18.3%).

In addition, the majority of the participants revealed normal cognitive health (62.2%). However, participants with moderate to high level of PA showed more frequently normal cognitive functioning compared to the ones with low level of PA (75% vs. 50%, $r = 0.27$, $p < .05$). Depressive symptoms were more pronounced in the low PA participants (34.2%), compared to the moderate to high PA level participants (13.9%, $r = 0.04$, $p < .05$).

Table 1 Participants socio-demographic characteristics (n=74)

	n	(%)	MO	TA
Men	60	81.1		
Women	14	18.9		
Age (Years)			80.80	7.643
Education				
Primary education	40	54.1		
High school (Gymnasium & Lyceum)	30	40.5		
College and more	4	5.4		
Mini Mental State Examination				
Normal cognitive function	46	62.2		
Cognitive impairment	28	37.8		
Depression symptoms				
No	56	75.7		
Yes	18	24.3		
Physical activity				
High/Moderate level	36	48.6		
Low level	38	51.4		
Sedentary behavior				
0-7 hour/day	57	77.0		
> 7 hour/day	17	23.0		

Spearman's correlation coefficient between the outcome variables is illustrated in Table 2. PA showed a significant negative correlation with cognitive function ($r = -0.26$, $p < .05$), depressive symptoms ($r = -0.24$, $p < .05$).

and SB($r=-0.26$, $p<.01$). Finally, SB was not found to be related to the cognitive function ($r=-0.08$, $p>.05$) and depression ($r=0.03$, $p>.05$).

The binary logistic regression results are presented in the Tables 3, 4, and 5. The results indicated that low PA levels were associated with higher probability of depressive symptoms (OR= 3.224, 95% CI: 1.013-10.266, $p<.05$). Based on the results, a participant with low level of PA is 3.224 times more likely to be depressed compared to the person with a moderate to high PA level. In addition, moderate/high PA level was associated with lower probability of cognitive decline (OR= 0.333, 95% CI: 0.124–0.894, $p<.05$). The relative odds for a person with a moderate/high level of PA to have cognitive impairment is 3 times less than a person with a low level of PA. Educational level of participants was associated with a lower probability of cognitive decline (OR = 0.269, 95% CI: 0.116 - 0.575, $p<.05$). As the level of education increases by one unit, the relative odds of a person having cognitive decline is 3.71 times less than a person with a low level of education. Also, sedentary life was not found to be associated with cognitive function and depressive symptoms. Finally, no significant correlations were revealed between gender and marital status with the examined variables.

Table 2 Spearman's Correlation Coefficient Between the Study's Variables

	IPAQ	GDS	MMSE	SB	Education
IPAQ	1				
GDS	-0.243*	1			
MMSE	-0.265*	0.142	1		
SB	-0.263**	0.032	-0.087	1	
Education	0.045	0.097	-0.415**	-0.064	1

Note: Spearman correlation; * $p<.05$, ** $p<.01$, *** $p<.001$ was considered as statistically significant

Discussion

This study aimed to examine the relationship among PA, cognitive function, depression, educational level, and SB in elderly people. Our findings are in accordance with previous studies showing a significant relationship between PA and depression and PA and cognitive function [41], [43]. Current PA guidelines for older adults emphasize the importance of a moderate to vigorous PA (≥ 150 min/week) (MVPA) for reducing the risk of Alzheimer's disease and for promoting cognitive health throughout their lifetime [15], [28]. Older adults without cognitive impairment who engage in regular PA have slower rate of cognitive decline [6]. Specifically, moderate to vigorous PA can reduce the risk of cognitive decline and dementia by 34% - 50% in the following 8 to 10 years [49].

Furthermore, PA improves global cognitive function, memory, language as well as executive functions such as processing speed in older adults with cognitive impairment [3], [12], [27], [48].

Regarding the impact of PA on depression, the present study showed a significant relationship between these two variables. This finding is in accordance with previous research results indicating that PA might have a positive impact on depression symptoms via both physiological and psychological pathways. More specifically, PA regulates the level of monoamines as well as the hypothalamic pituitary adrenal axis (HPA) which believed to lead to depression [5]. An additional hypothesis is that, exercise may reduce depression symptoms in older adults by regulating the adrenal hormones levels, such as adrenocorticotrophic hormone (ACTH), corticosterone (CORT) and cortisol [2]. From psychological point of view, PA may positively promote social relationships and social interaction in older adults. Additionally engaging in exercise programs may improve emotional well-being by enhancing older adult's feelings of enjoyment and self-esteem [60]. Several studies propose recommendations about the optimal intensity of PA which causes the most significant improvements in depressive symptoms in older adults. Some studies suggested that low-intensity PA may result in a great improvement in depressive symptoms [25], [32] while other studies noted that moderate- to - vigorous intensity PA had positive effects on depressive symptoms [37], [45].

Table 3 Relationship between PA and depression using binary logistic regression analysis

Physical activity	B	95% ConfidentInterval	Exp(B)	P value
Low level vs Moderate to high level	1.171	1.013- 10.266	3.224	.048

Note: $p < .05$ was considered as statistically significant

Table 4 Relationship between PA and cognitive function using binary logistic regression analysis

Physical activity	B	95% ConfidentInterval	Exp(B)	P value
Moderate to high level vs Low level	-1.099	0.124- 0.894	0.333	.029

Note: $p < .05$ was considered as statistically significant

Table 5 Relationship between education and cognitive function using binary logistic regression analysis

Education	B	95% Confident Interval	Exp(B)	P value
Primary	-1.313	0.116-0.575	0.269	0.004

Note: $p < .05$ was considered as statistically significant

In the present study, no significant relationships were observed among SB, depression, and cognitive function. A possible explanation is that by including just a single question (sedentary time) the IPAQ instrument provides general information about participants' sedentary life, it does not assess specific sedentary activities (e.g. watching TV, reading, etc.), and might not be sensitive enough to provide the specific information. In addition, participants may overestimate or underestimate the time spent in sedentary activities due to the inability to accurately recall specific information. Previous studies have reported the importance of indicating the type of sedentary occupation in terms of its influence on cognitive function and depression in older adults [21],[33]. In one of these studies, internet use improved participants cognitive status, while, in contrast, Maasackers et al (2019) study found no association between SB and cognitive function. Also, regarding depression, the study by Hamer and Stamatakis (2014), revealed that watching TV was associated with an increase of depressive symptoms, while on the contrary, engaging on internet activities and reading was associated with reduced depression. Regarding the hours of sedentary activities, it appears that being sedentary for eight or more hours per day is associated with higher odds of depression and cognitive impairment compared to sedentary activities that last less than eight hours per day [51],[55].

The findings of the present study revealed a close relationship between participants' educational level and their cognitive status. The higher the participants' education level the lower their cognitive decline, which suggests higher cognitive reserves for most educated people. Cognitive reserve theory proposes that older adults with higher cognitive function will have a lower risk of dementia than individuals with lower cognitive function [57]. Participation in educational programs even for a short period of time or in a late- life time can be effective in delaying cognitive impairment [16],[52].

In line with the findings of the present study, Balduino, de Melo, de Sousa Motada Silva, Martinelli and Cecato (2019) noted that older people with higher education level performed better in cognitive tests [4]. Also, a higher education level was associated with lower odds of cognitive impairment in ageing by protecting against executive and global function decline [40].

However, methodological limitations are inherent in the present study, and should not be overlooked. PA, SB and depression symptoms were assessed by self-report questionnaires which could result in self-referenced bias because of the subjective judgment, resulting individuals not represent their actual situation. Also, the findings should be examined with caution, as a cause-effect relationship cannot be supported between level of physical activity with depression and cognitive function as a cross-sectional study was applied to collect the data. A longitudinal research approach might support the causality among the examined variables. Also, the present study had a quantitative perspective, focusing mainly on participants' average values. However, significant inter- and intra-individual variability might exist that this approach is limited to fully capture participants' physical activity responses, depression, sedentary behaviour, and cognitive function. The small sample size and the low participation of women in the study should also be noted.

Conclusion

The findings of the present study suggest that PA improves psychological and cognitive status in older adults, by applying a positive effect of participants' depression and cognitive function. It was also found that the education level serves as an important element in cognitive health, reinforcing the need to carry out educational programs that promote the cognitive processes, autonomy, self-confidence, and quality of life of the elderly. With regard to SB, there is a need for future studies to explore further the types of sedentary behavior in order to identify the sedentary activities that have a negative impact on the cognitive function and mental health of older people, using sensitive neuropsychological instruments that provide objective information.

The present study provides an impetus for further research into the way increased activity may improve the quality of life in the future in humans, not only by preventing degenerative processes, but by also improving their psychological profile. Finally, the findings suggest that exercise may be a valuable short- and a long-term strategy for the self-regulation of mood in people with different

emotional and cognitive status. The current study clearly supports the positive effect of exercise in a person's emotional state. Successful ageing is the result of a combination of three components: (a) reduced likelihood of disease, (b) increased cognitive and physical function, and (c) active lifestyle [45]. It is important the society to "invest" in people's exercise participation, no matter of their age, through the promotion and information of citizens about the importance and benefits of exercise and the formation of the appropriate infrastructures that will allow people to have unhindered access to exercise areas.

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