



Research Paper: Physical Activity and Cognitive Function in the Elderly Population



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ABSTRACT

Background: Old age is accompanied by impaired musculoskeletal and nervous system, which may result in low mobility and cognitive problems.

Objectives: This study aims to evaluate the relationship between Physical Activity (PA) and Cognitive Function (CF) among the elderly population.

Materials & Methods: This is a descriptive cross-sectional study conducted on 200 old people who were members of retirement clubs in Mashhad City, Iran in 2017. They were selected using purposeful sampling method. To collect data, International Physical Activity Questionnaires (IPAQ), and Montreal Cognitive Assessment (MoCA) tools were employed. The Pearson correlation test and hierarchical regression analysis were used to determine the relationship and predictability of CF with PA, respectively after controlling intervening variable (age). Moreover, one-way Analysis of Covariance (ANCOVA) analysis was used to examine difference between CF scores in different PA levels.

Results: There was a positive and significant relationship between PA and CF in the elderly ($r=0.63$, $P<0.0001$). After controlling the age factor, PA was able to explain 42% of CF variance ($F_{2,197}=72.17$, $P<0.0001$). Moreover, ANCOVA results indicated that cognitive impairment was higher in the elderly with low PA ($F_{2,197}=54.40$, $P<0.0001$).

Conclusion: This study showed that lower PA was associated with higher cognitive impairment and older people with moderate and high PA had better CF than elderly with low PA. Therefore, suitable physical activity should be planned for the elderly to improve their ability in performing cognitive tasks.

Keywords: Physical activity, Cognition, Frail elderly

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Highlights

- There is a direct relationship between physical activity and cognitive function in the elderly.
- Cognitive impairment is higher in the elderly with low physical activity.
- Older people with moderate and high physical activity have better cognitive function than elderly with low physical activity.

Plain Language Summary

Old age is accompanied by impaired musculoskeletal and nervous system, which may result in low mobility and cognitive problems. This study aims to evaluate the relationship between physical activity and cognitive function in the elderly population. Two hundred old people, who were members of retirement clubs in Mashhad City, Iran in 2017, responded to International Physical Activity Questionnaires (IPAQ), and Montreal Cognitive Assessment (MoCA) tools. The results indicated a direct relationship between physical activity and cognitive functions in the elderly. After removing the age variable, physical activity explained about half of the changes in cognitive function. Moreover, cognitive impairment was higher in the elderly with low physical activity. Based on the study results, the elderly with a moderate to high physical activity have better cognitive functions. These results highlight the importance of interventions to increase physical activity because of its role in physical health, brain structure and function, and thus the improvement of cognitive function in the elderly. Therefore, proper physical activity should be planned for the elderly to improve their ability in performing cognitive tasks.

Introduction

Aging is not a pathological disorder, but it limits and impacts entire physical and mental activity. During this period, many changes in motor tasks are observed due to disorders in musculoskeletal system and body composition as well as psychological factors associated with aging [1]. In this period, a considerable reduction in muscle size and strength occurs called “Sarcopenia” which causes weakness, reduced mobility and functional autonomy, decreased quality of life, decreased stability, and increased risk of falling and mortality in the elderly [2].

Along with deteriorating changes in physiological and psychological functions, impaired functioning of the elderly, especially their nervous system increases. Also, because of the reduced speed of neurotransmitters and decreased brain volume and flexibility of neuronal cells, a major reduction in cognitive functions is observed in the elderly people [3]. Maintaining an active lifestyle plays a major role in improving the physical abilities of the elderly as it causes compatibility in different physical systems, providing oxygen and nutrients into cells, and improving the metabolic process, especially glucose regulation [4, 5].

Physical activity is defined as voluntary body movements which are produced by muscles and increase the energy consumption. These include activities performed as a part of daily life, such as walking, shopping, and climbing stairs. It is a behavioral factor related to the elderly people’ health and has a positive effect in reducing anxiety, stress, depression; maintaining mental health; and promoting quality of life [6]. Increasing age correlates with brain atrophy and loss of brain volume, i.e. it predicts brain deterioration and cognitive problems in old age. According to studies, lower to moderate level physical activity reduces the risk of cognitive impairment by 35% in people over 65 years old. It increases cell proliferation and cell longevity as well as the production of neurotransmitters in different neurological regions involved in cognitive functions [7, 8].

Epidemiological studies indicate that physical activity may play an important role in maintaining cognitive function throughout life and prevent cognitive deficits [9]. The elderly people who are constantly engaged in daily physical activities have significantly reduced age-related functional attenuation [10]. Findings of Loprinzi, Loprinzi et al., Van Uem et al., Brown et al. and Lerche et al. support a relationship between moderate physical activity and improving cognitive functions in the elderly with a disease as well as healthy ones [11-15].

There is limited information on how physical activity affects the prevention of cognitive problems as well as its relationship with cognitive function, especially in old age. However, we need to know how much and how long the physical activity is required to prevent cognitive impairments in aging. In this regard, this study was conducted to examine the relationship between Physical Activity (PA) and Cognitive Function (CF) in the elderly. Also we attempted to explain cognitive functions with respect to different levels of physical activity.

Materials and Methods

This is a cross-sectional study with descriptive correlational design. Study population consists of all elderly people aged 65 years or above living in Mashhad City, Iran who were members of retirement clubs during 2016-2017. Of these, 200 people aged 65-89 years were selected as study samples using purposeful sampling method. The sample size (97 males, 103 females) was determined in G*Power application according to the F value in ANCOVA analysis, the main effects of different levels of physical activity (low, moderate, and high), considering a maximum of three covariates, 95% confidence interval, 80% test power, and an average effect size of 0.25 [16].

The inclusion criteria were as follows: having an age of 65-90 years, having informed consent, lacking cognitive impairment (such as Alzheimer and vascular dementia) or acute physical-psychological illnesses based on medical records. The exclusion criteria were lacking cooperation; having speech, hearing, or vision problems; and bringing no hearing aids or glasses. For collecting data from the participants, International Physical Activity Questionnaires (IPAQ), and Montreal Cognitive Assessment (MoCA) tools were employed along with a demographic questionnaire. The participants first answered the demographic questions including age, gender, educational degree, and then other questions. But before the study, the participants were assured of the confidentiality of their information.

Study measures

IPAQ assesses PA in five domains of job, transportation, recreation, housework or related works in fields like as walking, moderate and hard chores. Results of PA are reported as MET-minutes/week, where 1 MET (metabolic equivalent) is equal to the energy consumption at 1 min rest. All physical activities can be categorized as coefficients of energy consumption at resting mode. In this questionnaire, the mild PA is 3.3 METs, moderate PA is 4.0 METs and high PA is 8.0 METs. To measure the total PA in a week, the amount of walking (MET×min×d) and the amount of moderate PA (MET×min×d), and high PA (MET×min×d) in the previous week are summed up. IPAQ categorizes PA scores as low (<600 MET), moderate (600–3000 MET) and high (>3000 MET) (IPAQ Research Committee). This tool has been already used in many studies and its validity and reliability have been approved [17].

MoCA with 30 items is widely used for detecting cognitive impairments in eight domains: short-term memory (delayed recall), visio-spatial skills (drawing cube, clock drawing), executive functions (digit and letter span, verbal fluency, abstraction), attention, concentration, working memory (deleting, subtraction, counting), language (naming, sentence repetition), and orientation to time and place. MoCA scores range between 0 and 30. A score of 26 or over is considered to be normal CF, and score of less than 26 indicates cognitive impairments [18]. The reliability and concurrent validity of the Persian version of this instrument have been reported as 0.77 and 0.79, respectively [19].

The collected data were analyzed in SPSS V. 20 considering the significant level of $P < 0.05$. The Pearson correlation test was used to determine the relationship between total IPAQ and MoCA scores. After controlling intervening variables (demographic variables), hierarchical regression analysis was used to examine the predictability of CF based on PA. Furthermore, 1-way ANCOVA was employed to determine differences between CF scores in three PA levels.

Table 1. Descriptive statistics of participants' PA and CF scores

Variables	Mean	SD	Range
Physical activity	982.14	82.35	99-4536
Cognitive function	19.12	8.12	3-30

Table 2. Hierarchical regression analysis results of MoCA based on IPAQ scores after modifying the intervening variable, age

Steps	Predictors	R ²	ΔR ²	SE _e	B	β	P
1	Age	0.028	0.023	8.029	-0.293	-0.0168	0.018
2	IPAQ	0.423	0.417	6.203	0.006	0.629	0.0001

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Table 3. ANCOVA results of MoCA scores considering PA levels after controlling age intervening variable

Groups	MoCA	SS	MS	F*	P
	Mean±SD				
Low activity	13.670±7.480	5830.034	2915.017	82.390	0.0001
Moderate activity	24.179±4.116				
High activity	27.818±1.470				
Total	19.1250±8.12400				

*df=2, 196.

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Results

Of 200 participants, 97 (48.5%) were males and 103 (51.5%) were females with a mean age of 65.99 years. Their mean years of study was 6.19 years ranged between 2 and 14 years. Table 1 presents mean and standard deviation of IPAQ and MoCA scores. The Pearson correlation test results indicate that PA has a significant relationship with CF ($r=0.63$, $P<0.0001$). This means that with the increase in IPAQ score, the MoCA score increases in the elderly people.

In order to identify intervening variables, the correlation between demographic factors and dependent variable (CF) was evaluated. The results of Pearson correlation coefficients indicated a significant and negative association between age and MoCA score ($r=-0.16$, $P=0.018$). i.e. with the increase of age, MoCA scores decreases. No relation was found between educational level and CF ($r=-0.073$, $P=0.306$). Results of Independent student t test also showed no significant difference between older men and women in term of MoCA scores ($t=0.471$, $df=198$, $P=0.638$). Therefore, age variable was considered as an intervening variable in this study and its effect on MoCA scores was statistically assessed in hierarchical regression analysis and one-way ANCOVA. Table 2 presents the results of hierarchical regression analysis.

The results of Durbin-Watson test ($DW=1.814$) indicate that the assumption of the independence of errors was met for performing regression analysis. According

to the results in Table 2, after identifying age factor as the control variable, R2 and adjusted R2 coefficients of the model were dramatically improved so that in the second step, about 42% of the changes in MoCA scores can be explained by IPAQ scores ($F_{2,197}=72.17$, $P<0.0001$). With regard to the beta coefficient of the predictive variable, with one unit increase in standard deviation of IPAQ score, the standard deviation of MoCA score increases 0.63 unit. With regard to the results and cut-off points of IPAQ, it was found out that the number of people with low energy consumption was 100 (50%), moderate consumption, 89 (44.5%) people and vigorous was 11 (5.5%) people.

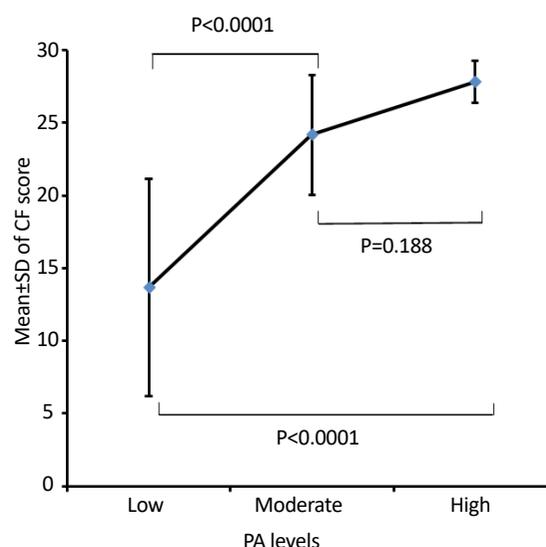


Figure 1. MoCA scores in three PA levels

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Table 3 presents ANCOVA results of MoCA scores considering three PA levels after controlling the age intervening variable. Before conducting ANCOVA, Levene's test results showed that the assumption of the equality of variances had been observed ($P > 0.05$). ANCOVA results showed a significant difference between the three groups of elderly with different PA levels (low, moderate, and high) in terms of CF score ($F_{2,196} = 82.39, P < 0.0001$).

In order to reveal which groups had a significant difference, the Games-Howell post-hoc test was used for paired comparisons, because it performs better than other post-hoc tests when the sample size between the groups is uneven and very different [20]. Figure 1 plots the differences of MoCA scores in three groups with low, moderate, and high PA. IPMoCA significantly IP; the difference is in favor of high PA. However, there was no significant difference between moderate and high PA ($P = 0.188$).

Discussion

The results of the research showed a positive and significant correlation between PA and CF. That is, with the increase in PA, the elderly's CF increases, too. This indicates that the PA of the elderly at home and at work, in doing sports and leisure-time activities associates with the improvement of their CF in terms of short-term memory, visio-spatial skills, executive functions, attention, concentration, working memory, language, and orientation to time and place. Loprinzi, Loprinzi et al., Van Uem et al., Brown et al. also reported a relationship between PA and CF in the elderly [11-14]. Erickson et al. showed that moderate PA is associated with increased CF, especially executive functions [8]. Their longitudinal study indicated that self-reported PA was associated with a 40% reduction in the risk of cognitive problems.

The results of our study also showed difference between the CF of the elderly and different levels of PA (low, moderate, and high). Those with low PA had more cognitive impairment than those with moderate and high PA; however, there was no significant difference between the two groups with moderate and high PA in term of CF score. It indicates that if the elderly has a moderate PA, they can be protected against cognitive impairments. Therefore, balanced PA is necessary to increase the natural capacity of the brain and its flexibility and improve CF and reduce the risk of dementia. Results of Kimura et al. [10] revealed that the elderly people with high PA significantly showed less functional attenuation of prefrontal activations during task-switching reaction time.

Regarding the relationship between PA and CF in the elderly and their better CF with moderate and high PA, it can be said that PA increases energy consumption during consciousness and improves CFs such as executive function and working memory [21]. Longitudinal studies have shown that high PA is correlated with increasing volume in the regions of hippocampus, frontal cortex, and caudate nucleus, which is associated with decreasing risk of cognitive impairments [8]. Also, the findings have shown that regular PA, from 6 months to one year, is associated with greater hippocampal and prefrontal cortex size, indicating the long-term protective effects of PA on CF [22].

Tian et al. showed that PA has correlation with white matter volume in frontoparietal and subcortical networks [23]. Regarding the role of PA in brain function, studies have shown that PA is more associated with increasing neurological efficacy in hippocampus, prefrontal, and cingulate regions during cognitive challenging activities [8]. Therefore, according to the results of the current study and the previous studies, PA affects the structure and function of the brain.

The elderly (naturally and inevitably), with the increase of age, are faced with atrophy and reduced brain volume resulting in functional problems; however, with restorative methods such as PA, they can slow down this declining process. Regular and long-term physical activity with increased volume of frontal and prefrontal area as well as subcortical networks such as hippocampus, caudate nucleus and cingulate regions help improve brain function, enhance performance in cognitive tasks like visio-spatial skills, executive function, attention, concentration, working memory, and language.

This study was limited to a specific region of Iran (northeast part) and the statistical population of the study only consisted of the members of retirement clubs. This fact reduces the generalizability of the results. Also, because of the cross-sectional nature of the research, the data cannot infer causality. Therefore, it is suggested to use larger samples and conduct longitudinal studies for better generalizability.

Given that the results indicated a direct and positive relationship between PA and CF of the elderly, for improving CF (which plays an important role in life and independent performance of the elderly), it is recommended that measures be taken for building facilities such as designing health roads and walking paths. Moreover, it is imperative to increase the public awareness of the elderly and their families about the benefits of PA and its effects

on physical and mental health, which encourages more PA in the workplace, home, entertainment and sports.

Conclusion

It was found out that the elderly with a moderate to high PA showed better CF. These results highlight the importance of interventions to increase PA because of its role in physical health, brain structure and function, and thus the improvement of CF in the elderly.

Ethical Considerations

Compliance with ethical guidelines

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors. Informed consent was obtained from all individual participants included in the study.

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Conflict of interest

The authors declare that they have no conflict of interest.

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