Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 10), Art 318, pp. 2504 - 2512, October 2022
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Exploring the effect of physical activity level on balance, aerobic performance and cognitive function in young sedentary individuals

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Published online: October 31, 2022
(Accepted for publication October 15, 2022)
DOI:10.7752/jpes.2022.10318

Abstract:
The study examined the effect of physical activity levels of young sedentary individuals on balance, aerobic performance and cognitive functions. The research group consisted of 44 young sedentary individuals (32 females; 12 males; age: 42.2 ± 9.6 years; the body height: 162.3 ± 7.8 cm, the body mass: 71.3 ± 14.6 kg, body mass index (BMI): 26.9 ± 5.1 kg/m^2). The subjects were divided into two groups ("less active" and "more active") according to the mean physical activity level of overall study sample. The short form of the International Physical Activity Questionnaire (IPAQ) was usedto estimate physical activity level (PAL). Static and proprioceptive balance performance was measured with the Sensamove Balance Test using the Miniboard device. Aerobic performance was evaluated with the 1-Mile Endurance Run/Walk Test. The Go/No-Go test and the d2 test of attention were used to determine cognitive functions. No significant difference was found in the comparison of the static balance performances of the more active and less active groups (p>0.05). It was determined that there was a significant difference in favor of the more active group in the proprioceptive balance performance results ($\chi_{(1)}^2$: 4.494; p>0.05; (Phi)^3: 0.32). The level of physical activity did not make a significant difference on cognitive functions such as the inhibition and attention levels of the participants. PAL also did not affect the aerobic performance of participants. While being more active does not have an effect on static balance, aerobic performance and cognitive functions, it may provide an advantage for proprioceptive balance.
Keywords: executive function, attention, endurance, inactive people, equilibrium performance

Introduction

An active lifestyle is important in preventing decreases in functional capacity with age (Westerterp, 2000). The most important element of an active lifestyle is to be part of a physical activity program. There are several studies that point out the positive effect of physical activity on life quality in matters of health (Balboa-Castillo, 2011; Davies et al., 2012; Rhodes, Mark and Temmel, 2012). Besides the specified factors related to health, when the effects of physical activity on the brain, especially the front hippocampus, was observed it was found that areas related to cognitive functions such as; the prefrontal lobe, had more developed synaptic structures and that neurogenesis, angiogenesis and brain blood flow accelerated (Dolu et al., 2016). Nevertheless, adults tend to be less active with advancing age, although it is well-known that physical activity is important for independent living, prevention of chronic health problems, and quality of life (Brill, 2004; Hardman and Stensel, 2003).

During the literature search, it was found that studies were mainly concentrated on older individuals. A study conducted by Brach et al. (2003) found a significant relationship between physical activity and functional condition by analyzing the physical activity and functional condition of 229 women with an average age of 74.2 years during a 14-year time period, and also put forward the importance of physical activity in order to maintain physical function. Aoyagi et al. (2009) analyzed the relationship between walking skills, upper and lower extremity isometric muscular force and static and dynamic balance through the physical activity data and physical fitness indicators of 170 individuals between the ages of 65 and 84 years, in a 1-year time period. As a result, the lower extremity function was found significantly better in the more active group. Hernandes et al. (2012) conducted a study on individuals older than 60 years by forming a 134-person exercise group and a 104-person control group. The study showed that the exercise group had significantly better functional and maximal exercise capacity, lower extremity muscular force, agility and static balance compared to the control group. Purath et al. (2009) identified that upper and lower extremity force and aerobic endurance have a significant relationship through their research on the physical activity of 34 individuals over the age of 60 years.

Twenty-seven studies met the inclusion criteria for a review (Carvalho et al., 2014) Of these, 26 studies have reported a significant association between physical activity and cognitive function in late life. Of the ten randomized controlled trials (RCTs), nine showed a positive correlation and one showed a non-significant

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correlation. (Fabre et al., 2002). Although these studies included both male and female subjects, one RCT by Floel et al. (2010) enrolled only elderly healthy female subjects. As compared with controls, the authors also found a significant benefit of physical exercise (aerobic training with a bicycle ergometer or treadmill) in this elderly female population. Therefore, the majority of the studies concluded that physical activity in later life confers a protective effect on cognition in elderly subjects (Carvalho et al., 2014). However, other studies have mainly focused on the association between physical activity and overall cognitive functioning in children. The results from a previous meta-analysis indicated a positive association between physical activity and overall cognitive functioning in children (Sibley and Etnier, 2003). Meta-analyses on studies investigating causal relationships exhibited significant positive effects of physical activity on children's executive functions (Verburgh et al., 2014).

According to the World Health Organization (WHO) criteria, individuals with the ages of 18-65 years are categorized as young (Beger and Yavuzer, 2012). Therefore, our sample group was defined as young adults. Studies in this field generally investigate the relationship between physical activity levels and functional elements in older individuals, while the relationship between physical activity levels and cognitive functions are researched in children. Hence, studies conducted on the relationship of physical activity level with both functional elements and cognitive functions are very limited. The results obtained from the present study are expected to be a contribution to the literature. The aim of the research is to put forward the effect of balance, aerobic performance, inhibition and attention parameters on physical activity levels of young sedentary individuals.

Material and Methods

Subjects

Forty-four young sedentary individuals (32 females; 12 males; age: 42.2 ± 9.6 years; the body height: 162.3 ± 7.8 cm, the body mass: 71.3 ± 14.6 kg, BMI: 26.9 ± 5.1 kg/m^2) participated in the study. In order for the participants to be included in the study, they had to meet the conditions that they should not have an orthopaedic, cardiological or neurological disease that would prevent the movements to be made in the measurements and tests, not to engage in forcible physical activity before the measurements, and not to use painkillers or sleep-inducing drugs the day before the measurements. The subjects were divided into two groups ("less active" and "more active") according to the mean physical activity level of the overall study sample. The mean values were calculated and utilized to perform grouping since the data were parametric. The less active group included the subjects whose mean physical activity level was lower than that in the overall study sample, and the more active group included the subjects with higher physical activity level than that in the overall study sample. The same procedure was used for grouping the subjects according to scores in the "balance tests", "1-mile endurance run/walk test", and "cognitive function tests"; these groups are referred to as "poor" and "good". All subjects signed and accepted the informed consent in accordance with the recommendations of the Helsinki Declaration for Human Research. The ethical approval was obtained from Tekirdag Namık Kemal University Scientific Research and Publication Ethics Committee (Protocol No: 2021.275.11.19) .

Table 1. Descriptive data on the age and anthropometric characteristics of the subjects

Variables	Mean	Sd
Age (year)	42.22	9.66
The body height (cm)	162.39	7.88
The body mass (kg)	71.34	14.69
BMI (kg/m2	26.97	5.11

Data are presented in mean ± standard deviation. Abbreviation: Sd = Standard Deviation

Measurement of Anthropometric Characteristics

Subjects' body height and body mass measurements were made while they were barefoot. A Mesilife 13539 brand portable height meter with accuracy of 0.1 cm was used for measurements. The participants were wearing only shorts and T-shirts during body weight measurements. The obtained values were recorded in the data sheet in kg (Karakoc, 2009). An Omron weighing device with an accuracy of 0.01 kg was used for the measurements. Body mass index (BMI) (kg/m^2) = was calculated according to the formula of body mass (kg) divided by body height squared (m^2) .

The Identification of Physical Activity

The short form of International Physical Activity Questionnaire (IPAQ) was used in the research. The participants between the ages of 15 and 65 years were subject to the questionnaire in order to define their physical activity levels (Craig et al., 2003). Turkish validity and reliability tests have been previously conducted (Öztürk, 2005). The IPAQ measurement was utilized, which suggests that physical activities be performed at least 10 minutes at a time. The questionnaire queried the participants' intensive physical activity time, moderate intensity physical activity time, walking time and sitting time within a day. Intensive, moderate intensity physical activity and walking times were converted to the corresponding basal metabolism in MET unit (1 MET = 3.5 ml/kg/min) with the calculations given below, and the total physical activity score (MET - min/week) was calculated.

Measurement of Balance Performances

Balance was assessed using a moveable platform (SensBalance Miniboard; Sensamove®, Utrecht, the Netherlands) that provides an interactive training tool. The participants were examined twice, assessing two balance tasks with two different conditions. The device used is based on innovative, non-invasive technology that allows real-time data recording and offers the possibility of storing them in the form of Notepad data files, Excel, and in the form of graphical files. The aforementioned measuring apparatus allow us to perform tests that looked at static and dynamic balance and ankle joint mobility (Liviu, Ilie & Fernando, 2018). However, in this study, participants' static and proprioception balance measurements were performed.

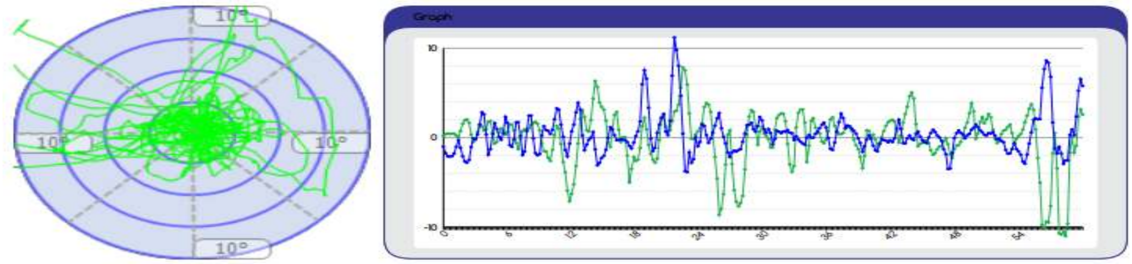

Fig. 1. Example of static balance test

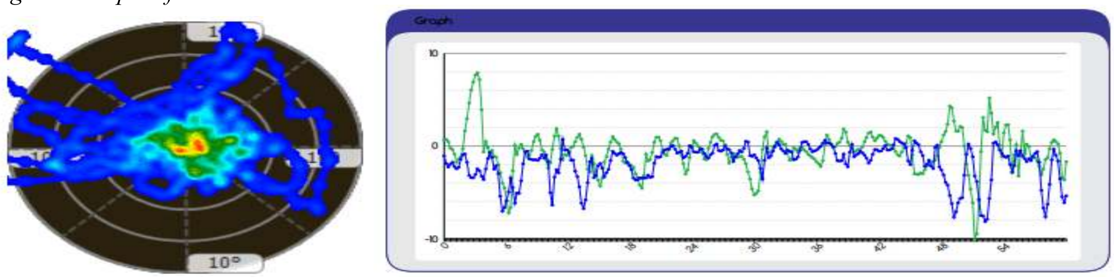

Fig. 2. Example of proprioceptive balance test

Measurement of 1-Mile Endurance Run/Walk Test

The one-mile endurance run or walk test is a commonly used run/walk test of aerobic endurance. The aim is to complete one mile in the fastest possible time. This test measures aerobic endurance, as a measure of health and an important component of many sporting activities. Before the pre-test, the test procedures should be explained to the subject. Then, screening of health risks is performed and informed consent is obtained. Forms are prepared and basic information is collected such as age, height, body weight, gender and test conditions. The course is measured, and cones are used to mark out it. The purpose of this test is to complete one mile in the fastest possible time. After the purpose of the test and instructions are given, the participants begin running on the count "Ready? Go!". If they desire, walking may be interspersed with running, however, they should be encouraged to cover the distance in as short a time as possible. The time, in minutes and seconds, took to complete the mile is noted. These results can be compared to published norms for similar age groups (Wood, 2008).

Male (VO2max) = 108.844 - 0.1636W - 1.438T - 0.1928H

Female (VO2max) = 100.5 - 0.1636W - 1.438T - 0.1928H

W = Weight in kg, T = Time for the one-mile run and H = Heart rate at the end of the run (George et al., 1993)

Measurement of Inhibition

The Go/No–Go Task simply tests the response inhibition by the restraining of a strongly established response (Farah, 2003). There are many versions of the tasks. Turkish standardization of Go/No-Go task has not been conducted yet. In this study, a computer-based Go/No-Go task was administered. X and O images were utilized as stimulants in the Go/No-Go task. The X image is the target stimulant (Go) whereas the O image is the non-target stimulant (No-Go). The participant's task is to click the left mouse button as quick as possible when the target stimulant is shown and to inhibit the urge to click the button when the non-target stimulant is shown. There are 200 stimulants within the task. 100 of them (50%) are target stimulants (Go) and the remaining 100 (50%) are non-target (No-Go) stimulants. Twenty-seven of the target and non-target stimulants are displayed on the screen (stimulus duration) for 50 milliseconds. After these stimulants there is a 1,450-millisecond black screen display. Therefore, the time period between the start of one stimulant to the start of the next stimulant (SOA) is 1,500 milliseconds. Also, the length of inter-stimulus intervals (ISI) is 1,450 milliseconds. The task takes approximately 5 minutes and 40 seconds. In the Go task, the number of correct reactions given by clicking the left mouse button on a target stimulant is the correct reaction score, the number of instances that a reaction is not given on a target stimulant is the incorrect reaction score, and the reaction time average of the correct reactions given to a target stimulant is the correct reaction latency. In the No-Go task, the number of instances that a reaction was not given on a non-target stimulant is the correct reaction score, the number of reactions given by clicking the left mouse button on the non-target stimulant is the incorrect reaction score, and the reaction time average of the correct reactions given to a target simulant is the incorrect reaction latency.

Measurement of Attention

The D2 attention test was employed in the identification of the participant's attention span. The D2 test is one of the methods used to measure selective attention and mental concentration levels. On the front page of this test, there is a part for the participant's personal information and the recording of the results along with a trial row. On the next page, the standard test form takes place. On each page of the test there are 14 rows with 47 marked letters. Each row has 16 different letters made up of "p" and "d" letters with one, two, three or four small markings on it. During the test, the participant must go over the rows and ignore irrelevant letters while identifying "d" letters marked with two and strike them out. The participant is given 20 seconds for each row. D2 Test scores and their descriptions are given below. (Brickenkamp and Zillmer, 1998; Spreen and Strauss, 1998). Total Matter Score Processed (TM) is the quantitative measurement of performance for all relevant and irrelevant processed matters.

Total Error (E) includes all non-marked (E1) and incorrectly marked (E2) letters. Error Percentage (E%) is the variant for measuring the qualitative aspect of the performance that gives the error rate of all processed matters. The decrease of the error rate increases the correctness of the participant, the quality of the work and the attention span. Concentration Performance (CP) is calculated by subtracting E2 from the number of correct strikes. Frequency Rate (FR) is the difference between the maximum number of processed matters and minimum number of processed matters. Total Matter-Error (TM-E) is found by subtracting the error score from the total number of reviewed matters. TM-E is a score that indicates the total performance and is highly reliable and also shows the measurement of the relationship between the correctness and the speed of the performance. The resulting TM-E scores are categorized into percentile intervals as follows: 50-60% is bad, 60-70% is mediocre, 70-85% is normal and over 85% is good.

Procedure

The subjects were informed about the assessments. All measurements were completed in two days. Demographics related to age, sex, medical history (chronic health status number), smoking habits, and other characteristics were recorded on the first day. The seven-day physical activity recall questionnaire (7 Day PARQ) was used to estimate the physical activity level of the subjects. The interview-administered questionnaire took 10–15 min to complete. The body height and body weight of the subjects were measured, and the body mass index (BMI) was calculated according to BMI= kg / m^2 formula. Afterwards, the static and dynamic balance tests were performed with a Sensamove balance system. At the end of the measurements of the first day, a 1-Mile Endurance Run/Walk Test was applied to the subjects. Before the subjects began the 1-Mile Endurance Run/Walk Test, the following standard explanation was provided: "You may stop if you have to but continue again as soon as you are able to".

Standardized encouragement phrases were delivered every 30 s during each 1-Mile Endurance Run/Walk Test with the following phrases: "you're doing well" and "keep up the good work". The heartbeat rate of the participants during the 1-mile walk-run performance and after the test was checked with a Polar brand heartbeat rate censor. Also, the participant's time to complete the 1-mile test was measured by a smart phone GPS system. The data obtained were used in the aerobic fitness level formula, and the aerobic values of the participants were calculated. On the second day of the research, the cognitive tests were conducted. The D2 attention test and Go/No-Go tests were administered to the participants, respectively.

The cognitive tests took place in a setting where only the participant and the test administrator were present. Also, the setting of the cognitive tests was cared to be silent and far from the factors that can be distracting. The tests and measurements were applied to the participants by the same researchers in the same order. Before the balance and aerobic endurance tests, the participants were allowed to perform a standard warm-up consisting of 10 minutes of jogging followed by 5 minutes of dynamic stretching. All tests were carried out at the same time of the day (17:30-19:30) to avoid the influence of circadian rhythms on the results of the study. After the completion of the tests, the participants were given the necessary time to perform cool-down exercises.

Statistical analysis

The Statistical Package for Social Sciences (SPSS 18.0 version) was used for the statistical analysis of the data collected. Some demographic data (age, body height, body weight, BMI) are presented as means with standard deviations (means ± SD), along with minimum–maximum values. Other demographic characteristics are given as numbers and percentages. The relationships between the functional fitness results and age or PAL were evaluated by chi-square analysis. The level of significance was accepted at 0.05 for each analysis.

Results

There was no significant effect of PAL on the static balance of the subjects. On the other hand, PAL showed a statistically significant effect on proprioceptive balance ($p<0.05$). The more active group had significantly better proprioceptive balance than the less active group. Also, the effect size of the statistical difference between both groups was determined as (Phi)3 = 0.32 (Table 2). It was found that PAL had no significant effect on the results of VO_2max and the attention and inhibition measurements (Table 3, 4, 5, 6).

Table 2. Effect of physical activity level on static and proprioceptive parameters

Level of physical activity	Static balance				χ2	p	Proprioceptive balance				χ2	p	$(Phi)^3$
	Poor		Good				Poor		Good				
	n	%	n	%			n	%	n	%			
Less active	9	29	22	71	0.910	0.46	18	58.1	13	41.9	4.494	**0.03***	0.32
More active	2	15.4	11	84.6			3	23.1	10	76.9			

p<0.05*

Table 3. Effect of physical activity level on VO_2max

Level of physical activity	VO_2max				χ2	p
	Poor		Good			
	n	%	n	%		
Less active	17	54.8	14	45.2	0.277	0.59
More active	6	46.2	7	53.8		

p<0.05*

Table 4. Effect of physical activity level on parameters of attention

Level of physical activity	TM				χ2	p	E1				χ2	p
	Poor		Good				Poor		Good			
	n	%	n	%			n	%	n	%		
Less active	13	41.9	18	58.1	2.730	0.09	18	58.1	13	41.9	0.482	0.48
More active	9	69.2	4	30.8			9	69.2	4	30.8		

p<0.05* TM: Total number of matters processed (Representing participants' psychomotor speed); E1: Non-marked letters (Representing the selective attention of the participants)

Table 5. Effect of physical activity level on the Go parameter of inhibition

Level of physical activity	GCR				χ2	p	GWR				χ2	p	CRL				χ2	p
	Poor		Good				Poor		Good				Poor		Good			
	n	%	n	%			n	%	n	%			n	%	n	%		
Less active	8	25.8	23	74.2	3.205	0.07	23	74.2	8	25.8	3.205	0.07	10	32.3	21	67.7	0.764	0.38
More active	7	53.8	6	46.2			6	46.2	7	53.8			6	46.2	7	53.8		

p<0.05* GCR: number of correct responses in the Go task; GWR: number of wrong reactions in the Go task; CRL: correct response latency in the Go task

Table 6. Effect of physical activity level on the No-Go parameter of inhibition

Level of physical activity	GCR				χ2	p	GWR				χ2	p	WRL				χ2	p
	Poor		Good				Poor		Good				Poor		Good			
	n	%	n	%			n	%	n	%			n	%	n	%		
Less active	8	25.8	23	74.2	3.205	0.07	23	74.2	8	25.8	3.205	0.07	18	58.1	13	41.9	0.046	0.83
More active	7	53.8	6	46.2			6	46.2	7	53.8			8	61.5	5	38.5		

p<0.05* GCR: number of correct responses in the No-Go task; GWR: number of wrong reactions in the No-Go task; CRL: wrong response latency in the No-Go task

Discussion

The aim of the research is to analyze the effects of physical activity levels on balance, aerobic performance and cognitive functions in young sedentary individuals. When comparing the proprioceptive balance performance of the physically more active group with that of the less active group; it was determined that there was a statistically significant difference in favor of the more active group. In a study conducted with individuals older than 65 years, a significant positive relationship was identified between physical activity and balance (Soyuer, Şenol and Elmalı, 2012). In another study, it was determined that the balance functions of elderly people who participated in the physical activity program were better than those who did not participate in a physical activity program (Rolland et al., 2007). In another research where the physical activity levels of university students were categorized as inactive, minimal activeness and very active, a significant difference was found in the comparison of static and dynamic balance performances according to physical activity level (Koc, 2018). It has been concluded that the static balance of elderly individuals participating in regular physical activity programs is better than that of inactive elderly (Daniel et al., 2010, Koyuncu et al., 2017). In a research conducted by Santos et al. (2012), the results showed that physical inactivity in elderly individuals have negative effects on dynamic balance. One of the main reasons of this finding was shown to be that physical inactivity leads to a decrease in lower torso performance (Salguero et al., 2011). Another research pointed out that PAL increase in elderly individuals increased the dynamic balance more than static balance (Duray, Akman and Yaşar, 2021). It was observed that studies have been focused on the effects of physical activity level on both static and dynamic balance. To the best our knowledge, there is no study in the literature examining the relationship between physical activity levels and proprioceptive balances.

In the study, it was found that there was a significant difference between the less active and more active groups in terms of the VO_2max value. Studies in the literature have shown strong evidence that physically active adults and elderly individuals have better cardiorespiratory levels and better biomarker profiles which prevent cardiovascular diseases, compared to less active individuals (Warburton, Nicol and Bredin, 2006; Warburton, 2007; WHO, 2010). Tuna (2010) revealed in their study on elderly individuals that physical activity levels do not have an effect on aerobic endurance. However, in a different study, it was stated that aerobic endurance reflects the physical capacity of the body and that aerobic endurance has a positive correlation with physical activity (Westerterp, 2000).The study by Sayın (2004) indicated that the 1-mile running time of both young girls and boys between the ages of 15 and 17 years decreases as their physical activity levels increase. In another study, no relationship was detected between the 6-Minute Walking Test (6 MWT) results and physical activity levels (PAL) in pre-adolescent boys (Ünver and Cinemre, 2017). On the contrary, Eiberg et al. (2005) and Dencker et al. (2006) established that physical activity levels and physical activity intensity have a low correlation with VO2max. Studies conducted on different populations showed that the relationship between physical activity levels and aerobic suitability can be in different degrees. It is thought that several factors, such as age, gender, body composition, etc. can be the cause of this circumstance.

In this study, it was determined that the physical activity levels of the participants did not have an effect on the attention and inhibition parameters that represent cognitive functions. In a study that aimed to compare the physical activity and D2 attention tests of a group of students between the ages of 12 and 14 years, the statistical evaluation revealed that the D2 attention test scores differed according to the physical activity level, and as the physical activity level increased, the error rate and the number of incorrect markings in the D2 attention test decreased. In addition, it was found that the number of incorrect markings and the error rate in the attention test negatively correlate with the level of physical activity (Avanoğlu, Karakaya and Hazar, 2020). A study focused on the analysis of the relationship between PAL and attention span (AS) in 11-year-old children, reported that there was no significant relationship between PAL and AS sub-parameters (İbiş et al., 2021). It is observed that studies about the relationship between physical activity and attention has been mostly conducted on children and adolescents. No studies were found on this topic towards the age group of the participants of our study. In a study in which elderly individuals over 65 years of age participated, it was concluded that there is a strong direct relationship between activity level and cognitive status, and that cognitive functions decrease with decreasing physical activity level (Lök and Lök, 2016). Klusmann et al. (2010) reported that the elderly who were inactive in terms of physical activity received low scores in the cognitive performance test evaluation. Sofi et al. (2011) indicated that the higher the physical activity levels of elderly individuals, the better their mental conditions. In another study with similar results, it was established that cognitive performance and physical activity levels have a positive, moderate and statistically significant relationship (İlhan, 2017). However, Tekkus et al. found no linear relationship between physical activity levels and cognitive performances in university students aged 18-25 years.

Conclusion

The sample size can be assessed as a limitation in the present study. In addition, the gender factor was not taken into account in the statistical analysis. Therefore, this can also be regarded as a limitation. In the literature, the relationship of physical activity levels with functional structure and cognitive functions has been studied in children, adolescents or the elderly. Studies about this topic conducted on the age group that constitutes the sample group of this research are very limited. In relation to that, the results of this study can be said to be of great significance. In the present study, it was determined that the group with higher physical activity level was in a better condition in terms of the proprioceptive balance level compared to the group with less physical activity, while no difference was found in terms of the other parameters. At this point, in future studies to be conducted on the topic, care should be taken to create study groups with large sample sizes and to take the gender factor into consideration.

Ethics declarations

Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

This study was conducted in accordance with the ethical standards indicated in the Ethics subsection at the beginning of the methods section.

References

Aoyagi, Y., Park, H., Watanabe, E., Park, S., & Shephard, R. J. (2009). Habitual physical activity and physical fitness in older Japanese adults: The Nakanojo Study. *Gerontology*, *55*(5), 523-531. https://doi.org/10.1159/000236326

Avanoglu, A. E., Karakaya, F., & Hazar, S. (2020). The research of relationship between physical activity and attention levels. *Sivas Cumhuriyet University Journal of Sport Sciences, 1*(1), 10-16.

Balboa-Castillo, T., León-Muñoz, L. M., Graciani, A., Rodríguez-Artalejo, F., & Guallar-Castillón, P. (2011). Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. *Health and Quality of Life Outcomes*, *9*(1), 1-10.

Beger, T., & Yavuzer, H. (2012). The epidemiology of aging and old age. *Clinical Development*, *25*(3), 1-3.

Brach, J. S., FitzGerald, S., Newman, A. B., Kelsey, S., Kuller, L., VanSwearingen, J. M., & Kriska, A. M. (2003). Physical activity and functional status in community-dwelling older women: a 14-year prospective study. *Archives of Internal Medicine*, *163*(21), 2565-2571. doi:10.1001/archinte.163.21.2565.

Brickenkamp, R., & Zillmer, E. (1998). *The d2 test of attention*. Seattle: Hogrefe & Huber Publishers.

Brill, P. A. (2004). *Functional fitness in older adul*ts. USA: Human Kinetics.

Carvalho, A., Rea, I. M., Parimon, T., & Cusack, B. J. (2014). Physical activity and cognitive function in individuals over 60 years of age: a systematic review. *Clinical Interventions in Aging*, *9*, 661–682. doi: 10.2147/CIA.S55520

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., ... & Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*, *35*(8), 1381-1395. DOI: 10.1249/01.mss.0000078924.61453.fb

Daniel, F., Vale, R., Giani, T., Bacellar, S., & Dantas, E. (2010). Effects of a physical activity program on static balance and functional autonomy in elderly women. *Macedonian Journal of Medical Sciences*, *3*(1), 21-6. doi:10.3889/MJMS.1857-5773.2010.0083.

Davies, C. A., Vandelanotte, C., Duncan, M. J., & Van Uffelen, J. G. (2012). Associations of physical activity and screen-time on health related quality of life in adults. *Preventive Medicine*, *55*(1), 46-49. https://doi.org/10.1016/j.ypmed.2012.05.003.

Dencker, M., Thorsson, O., Karlsson, M. K., Lindén, C., Svensson, J., Wollmer, P., & Andersen, L. B. (2006). Daily physical activity and its relation to aerobic fitness in children aged 8–11 years. European Journal of Applied Physiology, 96(5), 587-592. DOI: 10.1007/s00421-005-0117-1.

Dolu, N., Bahur, S., Demirer, F., Kulak, E., & Çam, A. (2016). The effect of physical activity on cognitive functions. *Izmir University Medical Journal, D(5)*.

Duray, M., Akman, T. C., & Yasar, P. (2021). Balance, physical activity and performance in the elderly living in community dwelling elderly. *Suleyman Demirel University Journal of Health Sciences*, *12*(1), 44-51.

Eiberg, S., Hasselstrom, H., Grønfeldt, V., Froberg, K., Svensson, J., & Andersen, L. B. (2005). Maximum oxygen uptake and objectively measured physical activity in Danish children 6–7 years of age: the Copenhagen school child intervention study. *British Journal of Sports Medicine*, *39*(10), 725-730. http://dx.doi.org/10.1136/bjsm.2004.015230.

Fabre C, Chamari K, Mucci P, Masse-Biron J, Prefaut C. Improvement of cognitive function by mental and/or individualized aerobic training in healthy elderly subjects. *International Journal of Sports Medicine.* 2002;23:415-421.

Farah, M. (2003). Frontal lobes: Cognitive neuropsychological issues. In E. T. Feinberg & J. M. Farah (Eds.), Behavioral neurology & neuropsychology (pp. 393-399). New York: McGraw Hill.

Floel A, Ruscheweyh R, Kruger K, et al. Physical activity and memory functions: are neurotrophins and cerebral gray matter volume the missing link? *NeuroImage.* 2010;49:2756–2763.

George, J. D., Vehrs, P. R., Allsen, P. E., Fellingham, G. W., & Fisher, A. G. (1993). VO2max estimation from a submaximal 1-mile track jog for fit college-age individuals. *Medicine and Science in Sports and Exercise*, *25*(3), 401-406.

Hardman, A. E., & Stensel, D.J. (2003). *Ageing, therapeutic exercise and public health. In physical activity and health: the evidence explained*. London: Routledge Taylor & Francis Group.

Hernandes, N. A., Probst, V. S., Silva Jr, R. A. D., Januário, R. S., Pitta, F., & Teixeira, D. C. (2013). Physical activity in daily life in physically independent elderly participating in community-based exercise program. *Brazilian Journal of Physical Therapy*, *17*, 57-63. https://doi.org/10.1590/S1413-35552012005000055

Ilhan, A. (2017). *Assessment of relationship between physical activity level, nutritional status and cognitive function in elderly*. Master's thesis. Ankara: Hacettepe University. Available from: https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp. Accessed 23 May 2022.

Karakoc, B. (2009). *Investigation of the aerobic and anaerobic form of frequently used field tests in young soccer players.* Master's thesis. Ankara: Ankara University. Available from: https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp. Accessed 16 May 2022.

Klusmann, V., Evers, A., Schwarzer, R., Schlattmann, P., Reischies, F. M., Heuser, I., & Dimeo, F. C. (2010). Complex mental and physical activity in older women and cognitive performance: a 6-month randomized controlled trial. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences*, *65*(6), 680-688. https://doi.org/10.1093/gerona/glq053

Koc, M. (2018). *Analysing the correlations between female university students' levels of physical activity, balance performance*. Doctoral Dissertation. Kayseri: Erciyes University. Available from: https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp. Accessed 17 May 2022.

Koyuncu, G., Tuna, F., Yavuz, S., Kabayel, D. D., Koyuncu, M., Özdemir, H., & Süt, N. (2017). The last station before fracture: Assessment of falling and loss of balance in elderly. *Turkish Journal of Physical Medicine & Rehabilitation*, *63*(1), 14-22. DOI: 10.5606/tftrd.2017.90757.

Liviu, M., Ilie, M., & Fernando, G. (2018). Determination of balance parameters as physical training factors in athletics. *Journal of Physical Education and Sport*, 18(5), 2054-2057. DOI:10.7752/jpes.2018.s5306

Lok, N., & Lok, S. (2016). The relationship between physical activity levels and cognitive status of the elderly New *Symposium*, 54(2), DOI: 10.5455/NYS.2016006

Ozturk, M. (2005). *A research on reliability and validity of ınternational physical activity questionnaire and determination of physical activity level in university students.* Master Thesis. Ankara: Hacettepe University. Available from: https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=Wu5qsjV2YfPTDWxXR0fOAQ&no=rbo_gkFabWbA8zRjgtVmwQ. Accessed 23 May 2022.

Purath, J., Buchholz, S. W., & Kark, D. L. (2009). Physical fitness assessment of older adults in the primary care setting. *Journal of the American Academy of Nurse Practitioners*, *21*(2), 101-107. https://doi.org/10.1111/j.1745-7599.2008.00391.x

Rhodes, R. E., Mark, R. S., & Temmel, C. P. (2012). Adult sedentary behavior: a systematic review. *American journal of preventive medicine*, *42*(3), e3-e28. https://doi.org/10.1016/j.amepre.2011.10.020

Rolland, Y., Pillard, F., Klapouszczak, A., Reynish, E., Thomas, D., Andrieu, S., ... & Vellas, B. (2007). Exercise program for nursing home residents with Alzheimer's disease: A 1-year randomized, controlled trial. *Journal of the American Geriatrics Society*, *55*(2), 158-165. https://doi.org/10.1111/j.1532-5415.2007.01035.x

Salguero, A., Martínez-García, R., Molinero, O., & Márquez, S. (2011). Physical activity, quality of life and symptoms of depression in community-dwelling and institutionalized older adults. *Archives of Gerontology and Geriatrics*, *53*(2), 152-157. https://doi.org/10.1016/j.archger.2010.10.005

Santos, D. A., Silva, A. M., Baptista, F., Santos, R., Vale, S., Mota, J., & Sardinha, L. B. (2012). Sedentary behavior and physical activity are independently related to functional fitness in older adults. *Experimental Gerontology*, *47*(12), 908-912. https://doi.org/10.1016/j.exger.2012.07.011

Sayin, N. (2014). *Relationship between physical activity levels and physical fitness of young (15-17 ages).* Master Thesis. Konya: Selçuk University. Available from: file:///C:/Users/Lenovo/Downloads/Documents/369913.pdf. Accessed 23 May 2022.

İbiş, S. , Aka, H. , Kurt, S. & Aktuğ, Z. B. (2021). A research on the study of physical activity levels motor skills and attention levels in children. *Mediterranean Journal of Sport Science*, *4*(2), 210-220. DOI: 10.38021/asbid.931302

Sibley, B. A., & Etnier, J. L. (2003). The relationship between physical activity and cognition in children: a meta-analysis. *Pediatric Exercise Science*, *15*(3), 243-256. https://doi.org/10.1123/pes.15.3.243

Sofi, F., Valecchi, D., Bacci, D., Abbate, R., Gensini, G. F., Casini, A., & Macchi, C. (2011). Physical activity and risk of cognitive decline: a meta-analysis of prospective studies. *Journal of Internal Medicine*, *269*(1), 107-117. https://doi.org/10.1111/j.1365-2796.2010.02281.x

Soyuer, F., Şenol, V., & Elmali, F. (2012). Physical activity, balance and mobility functions of 65 and over older people living at rest home. *Van Medical Journal,* 19(3):116-121.

Spreen, O., & Strauss, E. (1998). *A compendium of neuropsychological tests*. New York: Oxford University Press.

Tekkuş, B. (2021). Investigation of the relationship between physical activity and cognitive performance in young adults. *OPUS International Journal of Society Researches*, *18*(42), 5699-5714. https://doi.org/10.26466/opus.932629

Tuna, H. (2010). Effect of age and physical activity level on functional fitness of older adults. Doctoral Dissertation. İzmir: Dokuz Eylül University. Available from: http://hdl.handle.net/20.500.12397/10330. Accessed 17 May 2022.

Unver, E., & Cinemre, S. A. (2017). Relationship between physical activity level and 6 minute walk test in pre-pubertal boys. *Hacettepe Journal of Sport Sciences*, *28*(4), 194-204. https://doi.org/10.17644/sbd.310533

Verburgh, L., Königs, M., Scherder, E. J., & Oosterlaan, J. (2014). Physical exercise and executive functions in preadolescent children, adolescents and young adults: A meta-analysis. *British journal of Sports Medicine*, *48*(12), 973-979. http://dx.doi.org/10.1136/bjsports-2012-091441

Warburton, D. E., Katzmarzyk, P. T., Rhodes, R. E., & Shephard, R. J. (2007). Evidence-informed physical activity guidelines for Canadian adults. *Applied Physiology, Nutrition, and Metabolism*, *32*(S2E), S16-S68. https://doi.org/10.1139/H07-123

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: The evidence. *Cmaj*, *174*(6), 801-809. https://doi.org/10.1503/cmaj.051351.

Westerterp, K. R. (2000). Daily physical activity and ageing. *Current Opinion in Clinical Nutrition & Metabolic Care*, *3*(6), 485-488.

Wood, R. (2008). "President's Challenge Endurance Run / Walk Test." Topend Sports Website. https://www.topendsports.com/testing/tests/endurance-run.htm. Accessed 20 May 2022

World Health Organization, [WHO]. (2010). Global recommendations on physical activity for health. Available from: Accessed 24 May 2022.