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INVESTIGATION OF RELATIONSHIP BETWEEN PHYSICAL FITNESS AND ATTENTION LEVELS IN ATHLETE CHILDREN

RAZMERJE MED TELESNO ZMOGLJIVOSTJO IN POZORNOSTJO PRI OTROCIH ŠPORTNIKIH

ABSTRACT

Although it is known that physical fitness in children has an effect on cognitive functions, the relationship between physical fitness and attention levels is unknown in children who do regular sports. The aim of our study is to investigate the relationship between physical fitness and attention level in children aged 7-12 who do sports and to compare it with children who do not do sports. 55 athletes (25 boys; 30 girls) and 55 non-athletes (26 boys; 29 girls) participated in the study. The average age of the participants was 11.63±0.77, respectively; 11.80±0.67 years. Children participating in the study were divided into 2 groups as athletes and non-athletes. Physical fitness levels of the children were evaluated with the Eurofit Test Battery. Attention levels were determined using the Bourdon Attention Test (BAT). When the two groups were compared in terms of physical fitness parameters and attention levels, significant difference was found in favor of the athlete ($p<0.05$). While there is a significant relationship between some physical fitness parameter and BAT in athlete children ($p<0.05$); there was no significant relationship in children who were non-athletes ($p>0.05$). As a result of our study, it was found that the attention levels were more developed in athlete children with higher physical fitness parameters. Considering that attention deficit has an important place today, we suggest that children with attention deficit should be directed to sports activities and included in attention deficit treatments.

Keywords: physical fitness, attention, children, eurofit test battery, bourdon attention test

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IZVLEČEK

Čeprav je znano, da telesna pripravljenost pri otrocih vpliva na kognitivne funkcije, je razmerje med telesno pripravljenostjo in ravnjo pozornosti, pri otrocih, ki se redno ukvarjajo s športom, neznano. Cilj naše raziskave je raziskati razmerje med telesno pripravljenostjo in stopnjo pozornosti pri otrocih, starih 7-12 let, ki se ukvarjajo s športom, in jo primerjati z otroki, ki se ne ukvarjajo s športom. V raziskavi je sodelovalo 55 športnikov (25 fantov; 30 deklet) in 55 nešportnikov (26 fantov; 29 deklet). Povprečna starost udeležencev je bila 11,63±0,77; 11,80±0,67 let. Otroci, ki so sodelovali v raziskavi, so bili razdeljeni v 2 skupini (športniki in nešportniki). Stopnjo telesne pripravljenosti otrok smo ocenjevali s testno baterijo Eurofit. Stopnjo pozornosti smo določili z Bourdonovim testom pozornosti (BAT). Ugotovili smo pomembno razliko v telesni pripravljenosti v korist športnikom ($p<0,05$). Čeprav obstaja pomembna povezava med nekaterimi parametri telesne pripravljenosti in BAT pri otrocih športnikih ($p<0,05$); ni bilo ugotovljenega pomembnega razmerja pri otrocih, ki niso bili športniki ($p>0,05$). Ugotovili smo, da je bila raven pozornosti bolj razvita pri otrocih športnikih z višjimi parametri telesne pripravljenosti. Glede na to, da ima pomanjkanje pozornosti danes pomembno mesto, predlagamo, da bi otroke s pomanjkanjem pozornosti usmerili v športne aktivnosti in jih vključili v zdravljenje pomanjkanja pozornosti.

Ključne besede: telesna pripravljenost, pozornost, otroci, eurofit testna baterija, bourdonov test pozornosti

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INTRODUCTION

Physical fitness; it is the capacity to perform physical activity and refers to a number of physiological and psychological qualities. Physical fitness can be considered as an integrated measure of many, if not all, of body functions (musculoskeletal, cardiorespiratory, psychoneurological, and endocrine-metabolic) that play a role in the performance of physical activity and / or physical exercise. Therefore, when physical fitness is tested, the functional levels of all these systems are checked. The reason why physical fitness is considered one of the most important health indicators today is that it is also a predictor of cardiovascular disease and morbidity and mortality for all these reasons (Blair et al., 1995; Mora et al., 2003; Myers et al., 2002).

Attention; it is the mind's owning of one of several objects or sets of thoughts that are possible at the same time. Attention means withdrawing from certain things in order to deal effectively with others, and it is a situation that has a real contrast in a confused, confused, scattered state. Attention is also defined as the mental ability to choose relevant stimuli, responses, memories, or thoughts, as well as stimuli that are behaviorally irrelevant (Corbetta, 1998; Jääskeläinen and Ahveninen, 2014).

In recent years, evidence has accumulated that physical activity, sports, and cardiovascular fitness are positively associated with cognitive functions. Structural and functional brain changes have also been associated with physical activity. While a few studies have shown the benefits of physical activity on cognitive functions, little is known about how it improves cognitive functions (Bherer, Erickson, and Liu-Ambrose, 2013; Erickson, Hillman, and Kramer, 2015). As a result of physical fitness, it has been observed that there is an increase in gray matter volume in some regions of the brain. It was observed that the volume increases occurred mostly in the cortical and subcortical regions (Landrigan, 2019). It is suggested that neurotrophic factors and plasticity in the brain are responsible for such a result. Cognitive enhancement as a result of physical activity in children is indispensable for lifelong success and is a prerequisite for successful learning (Chang, Labban, Gapin, and Etnier, 2012; Verburgh, Königs, Scherder, and Oosterlaan, 2014). Several underlying mechanisms may explain the effects of physical activity and sport on cognitive functions. Firstly, it is thought to increase the physiological arousal level of the child immediately after a physical activity, which facilitates cognitive Performance (Audiffren, 2009; Tomporowski, 2003). From a psycho-physiological perspective, physical activity triggers an increase in neurotransmitters (e.g., epinephrine, dopamine, brain-derived neurotrophic factors) that are thought to improve cognitive processes (Dishman et al., 2006; Roig, Nordbrandt, Geertsen, and Nielsen, 2013). Second, according to the cardiovascular fitness hypothesis, continuous physical activity increases cognitive performance and aerobic fitness (Etnier et al., 1997). This hypothesis is supported by the claim that physical activity increases angiogenesis (Isaacs, Anderson, Alcantara, Black, and Greenough, 1992).

Although it is known that physical fitness has an effect on cognitive functions in children, the relationship between physical fitness and attention levels in children who do sports regularly is unknown. Therefore, the aim of our study is to investigate the relationship between physical fitness and attention level in children aged 7-12 who do sports and to compare it with children who do not do sports.

METHODS

Participants

The study was planned as a cross-sectional study. Children who were athletes studying at a local basketball sports academy between August-November 2020 were included in the study. The children participating in the study were divided into 2 groups as athletes and non-athletes. Inclusion criteria for athlete children; being between the ages of 7-12, having been doing sports regularly for the last 1 year, and volunteering to participate in the study is provided by both the family/ guardian and the child. The inclusion criteria for non-athletes; being between the ages of 7-12, not doing sports regularly, and volunteering to participate in the study is provided by both the family/guardian and the child. The exclusion criteria for both groups are; the presence of a known cardiac, neurological or orthopedic health problem, a history of neuromuscular injury in the last 6 months, pain during the evaluation, and not volunteering to participate in the study. Before starting the study, participants were informed about the study and signed the volunteer form parental consent forms indicating that they participated voluntarily. Before starting the study, necessary permissions were obtained from the Ethics Committee of XXX (Date: 02/07/2020 - No: 2020-09 / 75).

Assessments

The demographic information of the participants was evaluated with the case report form, their physical fitness level with the Eurofit Test Battery, and their attention levels with the Bourdon

Attention Test. Descriptive information such as age, gender, height and weight were obtained in the case report form.

Physical fitness level

In order to measure the physical fitness levels of the participants, the European Council of Ministers Council used the Eurofit Test Battery, which they standardized in their book "Sport" in 1988 to investigate the physical fitness Eurofit test. Eurofit Test Battery consists of 9 subtests such as balance, flexibility, arm movement speed, muscular strength, abdominal muscle strength, muscular strength, running speed, agility and anthropometric properties (Erikoğlu, Güzel, Pense, and Örer, 2015).

Attention level

The Bourdon Attention Test was used to assess the attention levels of the participants. The test developed in 1955 by Benjamin Bourdon. Turkish validity and reliability studies were carried out by Karaduman (Karaduman, 2004).

Statistical Analysis

SPSS 22.0 package program was used for statistical analysis of the data. Coefficient of Variation, Detrended Plot, Histogram plot, Kolmogorov-Smirnov, Shapiro Wilk and Skewness-Kurtosis values were used to evaluate the normality of the data. Values are given as mean ± standard deviation. Since the data did conform to normal distribution, Pearson Correlation analysis was used to calculate the correlation between variables. Independent Samples T test was used for comparison between groups. The study results of Rodriguez-Ayllon et al. were taken as reference in calculating the sample size in our study (Rodriguez-Ayllon, 2018). In the analysis performed with the G*Power Software (Version 3.1.9.2, Dusseldorf, Germany), it was determined that 55 individuals should be included in each group at the 95% confidence interval and 80% power. Significance level was accepted as $p<0.05$.

RESULTS

Demographics

A total of 110 children, 55 athletes and 55 non-athletes, were included in the study. There is no significant difference between the groups in terms of age, height, weight and body mass index ($p> 0.05$) (Table 1).

Table 1. Demographic information of children in the athlete and non-athlete groups.

Assessments	Athlete Group (Mean±sd)	Non-athlete Group (Mean±sd)	t	p
Age *(years)*	11.63±0.77	11.80±0.67	-1.176	0.242
Length *(cm)*	170±7.40	165.12±8.39	0.905	0.368
Weight *(kg)*	56.04±17.88	54.71±13.73	0.437	0.663
BMI *(kg/m²)*	20.06±4.78	19.78±3.57	0.816	0.738

*BMI: Body Mass Index, *p<0,05, sd: Standard deviation

Physical Fitness Level and Attention Level

The mean and standard deviation of the physical fitness and attention level test results of the children in the athlete and non-athlete groups are shown in Table 2. A significant difference was found between the groups in favor of the athletes in all sub-dimensions of the Eurofit test battery and in the Bourdon attention test.

Table 2. Comparison of athlete and non-athlete group physical fitness and attention level test results.

Assessments	Athlete Group (Mean±sd)	Non-athlete Group (Mean±sd)	t	p
Flamingo Balance Test	9.09±4.16	12.80±5.02	**-4.125**	**<0.001***
Plate Tapping Test (sec)	12.68±1.74	16.62±3.01	**-8.403**	**<0.001***
Sit-and-reach Test (cm)	27.65±4.78	25.14±3.27	**3.209**	**0.002***
Standing Broad Jump Test (cm)	157.69±33.47	132.61±29.55	**4.164**	**<0.001***
Handgrip Test (kg)	14.02±4.60	11.23±3.75	**3.492**	**0.001***
Sit-Ups Test (repetitions, n)	19.67±5.17	14.21±4.02	**6.167**	**<0.001***
Bent Arm Hang Test (sec)	15.11±9.55	11.16±12.19	**1.890**	**0.041***
10x5 meter Shuttle Run (sec)	18.82±3.36	23.60±2.60	**-8.436**	**<0.001***
Bourdon Attention Test	102.05±7.82	85.45±7.97	**11.021**	**<0.001***

*p<0.05, sd=Standard deviation.

The relationship between the physical fitness levels and attention levels of the children in the athlete and non-athlete groups is shown in Table 3. Accordingly, a weak and positive relationship was found between the hand grip test and attention level in sports children (r=0,324, p=0,016). Similarly, a positive weak and significant relationship was found between the hanging test with bent arm and attention level (r=0,337, p=0,012). However, no significant relationship was found between physical fitness and attention levels in the non-athlete group (p> 0.05).

Table 3. The relationship between the physical fitness and attention level of the children in the athlete and non-athlete groups.

Physical Fitness Level Assessments	Attention Level			
	Athlete Group		Non-athlete Group	
	r	p	r	p
Flamingo Balance Test	-0.094	0.495	0.045	0.743
Plate Tapping Test (sec)	0.098	0.479	0.077	0.575
Sit-and-reach Test (cm)	0.004	0.974	0.110	0.424
Standing Broad Jump Test (cm)	**0.267**	**0.049***	-0.047	0.736
Handgrip Test (kg)	**0.324**	**0.016***	-0.045	0.743
Sit-Ups Test (repetitions, n)	**0.311**	**0.021***	-0.111	0.420
Bent Arm Hang Test (sec)	**0.337**	**0.012***	0.254	0.061
10x5 meter Shuttle Run (sec)	-0.139	0.312	-0.114	0.407

*p<0.05

DISCUSSION AND CONCLUSIONS

The study aimed to explore the relationship between physical fitness and attention level among athlete children and compare with non-athlete children. It was found that the physical fitness parameters of the athlete children were significantly different from the non-athlete children. There was no significant relationship between physical fitness and attention levels of the non-athlete group children, but a meaningful and positive relationship was found between specific physical fitness parameters and attention levels of the athlete children.

Successful playing of most team sports (such as football, basketball, hockey) requires knowledge of the positions of other players as well as an understanding of how these positions will change over time. Attention plays an important role in sports activities. Similar to attention in sports activities, there is a need to evaluate the situation in order to be aware of the complex and rapidly changing environment and to react accordingly. In sports, dribbling, making a sudden accurate and surprising pass, reaction to the opponent's movements are activities/moves that require attention. When these are taken into consideration, it can be explained why the attention levels of athlete children are higher than non-athlete children.

Several studies in the literature revealed that physical fitness and participation in physical activities improved children's mental functions. Studies have consistently shown that more physically fit children had better cognitive functions than less fit children (Donnelly et al., 2016). In a study on 25 children aged 8-12 years and diagnosed with attention-deficit hyperactivity disorder, Tantillo et al. (Tantillo, Kesick, Hynd, and Dishman, 2002) argued that intense short-term exercise had a positive effect on attention level, especially by affecting the catecholaminergic and dopaminergic systems in the brain. Physical fitness is also thought to improve cognitive performance as it increases hippocampal volume, basal ganglia volume, and functional neural connectivity in cognitive processes (Chaddock et al., 2010). Studies have shown that cardiovascular fitness, muscle strength, agility, balance, motor coordination, and flexibility are associated with cognitive improvements in adults and children (Budde, Voelcker-Rehage, Pietraßyk-Kendziorra, Ribeiro, and Tidow, 2008). Besides, it was seen in a functional magnetic resonance imaging study (fMRI) that individuals with higher physical fitness exhibited higher levels of activation in certain areas of the brain during cognitive tasks (e.g., frontoparietal network) (Voelcker-Rehage, Godde, and Staudinger, 2010). Chaddock and Netz (Chaddock, Hillman, Buck, and Cohen, 2011; Netz, Dwolatzky, Zinker, Argov, and Agmon, 2011) suggested that people with high physical fitness levels displayed more complicated cognitive functions than people with lower physical fitness levels. Majorek et al. (Majorek, Tüchelmann, and Heusser, 2004) showed that physical activity, sports, and movement therapies play an essential role in overcoming attention deficit hyperactivity deficit in children. Following the literature findings, the study concluded that athlete children with higher physical fitness had significantly better attention levels than the non-athlete group children. It may be due to the changes in the hormonal and neural bases involved in cognitive processes in the brain among the children who do physical activity and sports.

Chang et al. (Chang et al., 2014) examined the relationship between cardiovascular fitness and cognitive performance among healthy young adults by having them complete 30 minutes of moderate-intensity cycling. The researchers applied the Stroop test to measure the participants' attention levels before and after the exercise. The test results indicated that the participants with high cardiovascular fitness had better attention levels that also improved after exercise. Pontifex et al. (Pontifex, Hillman, and Polich, 2009) found that young adults with higher cardiovascular fitness showed better performance in distinguishing perceptual stimuli. They also stated that physical fitness, which changes by life span and age, affected selective attention, and there was a significant relationship between physical fitness and age. Contrary to the literature, in the current study, no significant relationship was found between the 10*5-meter shuttle running test, which assessed cardiovascular fitness, and attention level among athlete children, which might stem from that higher cardiovascular fitness suppressed external neural activity that facilitated attention (Colcombe et al., 2004).

No study in the literature examined the relationship between handgrip strength and cognitive functioning among children. However, some studies addressed the relationship between handgrip strength and cognitive performance in the elderly. For example, in their study on the elderly, Kobayashi-Coya et al. (Kobayashi-Cuya et al., 2018) reported that handgrip strength and hand motor skills were closely associated with cognitive performance (Kobayashi-Cuya et al., 2018). The current study found a significant relationship between handgrip strength and attention levels in athlete children, which overlaps with the literature findings. It may be standard neural processes between the central nervous system's cognitive and motor areas and the motor neurons of the peripheral nervous system (Haggard, 2005; Leisman, Moustafa, and Shafir, 2016). However, handgrip strength effects on cognitive performance are still unclear, and future studies can investigate that relationship.

In their study on healthy adults between the ages of 19 and 65, Rogge et al. (Rogge et al., 2017) divided the participants into two groups: those who received balance training and relaxation training. Pre and post-test results showed that balance performance significantly improved among those who received the balance training. Moreover, the researchers found a profound improvement in memory and spatial cognition in those participants (Rogge et al., 2017). Yoon et al. (D. Yoon, Lee, and Song, 2018) found that muscle strength, balance, and walking speed were correlated with cognitive functions and argued that physical fitness improved cognitive functioning. In the literature, human balance performance was associated with the volume of the hippocampus, basal ganglia, frontal, and parietal brain regions that play a role in cognitive performance (Hüfner et al., 2011; Niemann, Godde, Staudinger, and Voelcker-Rehage, 2014). However, there was no significant relationship between balance levels and attention levels in the current study, which might result from age-related changes in children’s cognitive functions. Therefore, it is suggested to explore the differences between age groups using a broader population.

No study in the literature reviewed the relationship between flexibility and cognitive performance in children. Hence, our study is a pioneer in analyzing the relationship between flexibility and cognitive functions in children. The study findings indicated no meaningful relationship between flexibility and attention levels among athlete children, which might stem from the fact that flexibility is at maximum level during childhood and gradually decreases with age. However, the relationship between flexibility and cognitive performance is still unclear, and new research is needed to identify it.

One of the main motoric properties of the Eurofit test battery is the touch test that measures the reaction time (Lieberman and McHugh, 2001). Reaction time is a variable related to sports and other daily life tasks (Metin et al., 2016; Sant’Ana, Franchini, da Silva, and Diefenthaeler, 2017). It refers to the time elapsed from a stimulus to response and is a functional instrument to evaluate the cognitive system's information processing capacity (Jensen, 2006; Kuang, 2017). Reaction time is characterized by the detection of the first stimulus, information transfer through afferent nerves, response generation in the central nervous system, and the speed of sensorimotor reaction (Adleman et al., 2016; Greenhouse, King, Noah, Maddock, and Ivry, 2017). Several factors affect reaction time: age, gender, and physical fitness (Der and Deary, 2006). Gentier et al. (Gentier et al., 2013) stated that engaging in physical exercise and physical fitness development enhance the capacity to respond directly to a stimulus and indirectly improve cognitive functioning. In their study of Pontifex et al. (Pontifex et al., 2009) grouped the participants into two considering their physical fitness and found that higher cognitive performance in young adults was associated with better reaction time (Pontifex et al., 2009). There was no relationship between the tapping test in our study, which evaluated the reaction time and attention levels in athlete children. It might stem from that reaction time performance in children develops with age. However, very few studies investigated the relationship between reaction time and cognitive performance, and therefore the relationship between them is still unclear. Future studies should attempt to clarify that relationship.

Children who engage in sports during childhood are more likely to be physically active in adulthood than non-athlete children (Tammelin, Näyhä, Hills, and Järvelin, 2003). Although doing sports is popular among children, some studies stressed that participation decreases, especially during adolescence (Zimmermann-Sloutskis, Wanner, Zimmermann, and Martin, 2010). There are two critical rationales for focusing on sports and physical activity in children: The first aim is to promote physical health and well-being during childhood; and ensure lifelong health by encouraging an active life and physical activity (Sallis and Patrick, 1994). In their study on the relationship between cognitive functions and Quadriceps muscle strength, Chen et al. (Chen et al., 2015) applied the Digit Symbol Substitution Test (DSST) to assess cognitive functioning and carried out isokinetic measurements to evaluate Quadriceps muscle strength. The study results found a significant relationship between lower extremity muscle strength and cognitive functions (Chen et al., 2015). Yoon et al. (D. H. Yoon et al., 2017) divided the participants into two groups to explore the effect of resistance exercises with elastic bands on cognitive functioning. One group was given a low-load resistance exercise with an elastic band, another was exposed to high-load resistance exercise with an elastic band. The findings showed a significant increase in muscle strength and cognitive functioning in both groups, and that the cognitive functioning was higher in the group that exercised at high speed (D. H. Yoon et al., 2017). In another study, Herold et al. (Herold, Törpel, Schega, and Müller, 2019) stated that resistance exercises and activities that improve muscle strength boosted executive functioning, especially in the frontal lobe. Moreover, resistance exercises led to higher white matter hypertrophy. In parallel with the literature, the current findings emphasized a significant relationship between attention level and the muscular strength and endurance in athlete children, such as the bent arm hanging test, which might be explained by the view that doing sports causes hypertrophy in muscles. In turn, it results in muscular strength and endurance.

In this study, the relationship between physical fitness level and attention level in athlete children was examined and compared with non-athlete children. Findings show that there is a relationship between physical fitness level and attention level in athlete children. A similar relationship could not be demonstrated in non-athlete children. Briefly, athlete children were more competent than non-athlete children in physical fitness and attention. Since specific physical fitness parameters and attention levels are interrelated, these results should be considered in planning training, physical activity, and rehabilitation programs to improve children's attention levels. In the light of previous studies and our findings, we suggest that children with attention deficit should be directed to exercise regularly. In addition, team sports activities can be included in the treatment of attention deficit.

Declaration of Conflicting Interests

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

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