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Body composition, cardiovascular fitness and attention of school-aged male children practicing sports club activities: A cross-sectional

Bahar Ates, Halil Tanir, Yasin Akinci

Abstract:

BACKGROUND: The positive effects of physical activity on physical fitness, bone health, academic achievement, cognitive functions, mental health, and reduced obesity have been proven. This study aims to investigate the relationship between sports club activities, physical activity selected health-related fitness, and the d2 attention test.

MATERIALS AND METHODS: A cross-sectional study was conducted in different sports clubs. A total of 78 male students aged 10-13 years participating in various branches of sports clubs were included in the study, 42 of whom were assigned to the sports group and 36 to the control group. Questionnaires were administered to assess sports club participation and attention levels, while physical health profiles were tested with body composition and Yo-Yo IR1C performance measures. Data were analyzed according to sports participation and the five most frequently reported sports. The means and standard deviation of each study value were calculated for the total subjects and by participating in sports activity using the IBM SPSS (version 23) analysis program. Data normality was checked and confirmed by the Skewness and Kurtosis Tests.

RESULTS: The results showed that boys enrolled in a sports activity had lower body mass (-17.9%, $P < 0.05$ d = 0.72), body mass index (-13.4%, $P < 0.05$, d = 0.87), and body fat (%) (-54.1%, $P < 0.05$, d = 1.38) and higher VO_2max 32.3% ($P < 0.05$, d = 3.67), than the non-active group. The boys active in sports clubs also had better results in the total number of items processed (11%, $P < 0.05$ d = 0.50) and in concentration performance (17.7%, $P < 0.05$ d = 0.56) than the non-active group. In correlation analyses, VO_2max was negatively associated with body mass, body mass index, and body fat ($P = 0.011$; $P = 0.001$ and $P = 0.00$, respectively) and positively related to the total number of items processed and concentration performance ($P = 0.003$ and $P = 0.015$, respectively). In the Pearson Correlation analyses, body fat showed a lower negative correlation with TN (r = 0.33; $P = 0.003$) and CP (r = 0.28; $P = 0.015$).

CONCLUSIONS: Boys participating in regular sports have lower body mass, BMI, and BF values. In addition, boys who participated in sports showed higher imaginary fitness and selective attention and concentration capacity results, as expected, for any sports part compared to their body peers. Another attempt from this study is that body mass and body fat percentage recovery are negatively associated with fitness. Considering the increasing prevalence of obesity in children and adolescents due to sedentary living, which has become a worldwide epidemic, it is recommended that pedagogical and public health strategies and policies be developed based on the physical fitness level of children.

Keywords:

Attention, children, club participation, health-related fitness, physical activity

Department of Coaching Education, Faculty of Sport Science, Usak University, Usak, Turkey

Address for correspondence:
Dr. Halil Tanir, Faculty of Sport Science, Usak University, Usak, Turkey.
E-mail: halil.tanir@usak.edu.tr

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Introduction

A structured physical activity program has many health benefits.[1] Physical activity (PA) is reported to have an important role in protecting the health of children and adolescents.[2] Therefore, ensuring the participation of children and adolescents in physical activity is considered important for public health. Studies in the literature have reported physical and physiological benefits of PA in children and adolescents such as obesity, body weight management, improvement of cardiovascular fitness (blood pressure, lipid profile, insulin sensitivity, endothelial function, etc.), and increased bone mineral density.[3,4] There are also many studies that elicit that regular participation in sports has positive effects on cognitive skills, academic achievement, concentration, and psychosocial functions in children.[5-7]

The theoretical framework of this research is the Precede-Proceed model, one of the most comprehensive and widely used approaches to community health promotion. The model has provided guidance in the fields of health education and health promotion since Lawrence Green[8] first developed Precede in 1974 and Green and Kreuter[9] added Proceed in 1991. This model aims to improve overall ecological health and quality of life by starting from the individual in democratic and participatory ways.

In a recent study, Bull *et al.*[10] reported that PA is positively associated with physical and mental well-being in children and adolescents. In a study supporting this view, Berki and Tarjanyi[11] reported that students who participated in sports activities had better general health levels, felt better, and had higher academic achievement levels.

Children should be encouraged to participate in regular physical activity due to the physical, physiological, cognitive, and psychosocial benefits mentioned above. In this context, WHO recommends that children and adolescents aged 5-17 years should engage in at least 60 minutes of moderate or vigorous physical activity every day of the week, plus muscle and bone strengthening activities at least 3 days a week.[8] However, despite all these recommendations and warnings, there has been no global improvement in inactive lifestyles, so WHO is making new recommendations in the 2018-2030 physical activity action plan, aiming to reduce this situation by 15%.[10]

In recent years, technological advancements have taken place in the modern world.[11] Increasing screen time with developing technology is seen as a source of many problems that threaten health and development in children and adolescents, such as physical inactivity, sleep disorders, and disruption of dietary patterns. The rapidly increasing sedentary lifestyle, especially in children, directly affects childhood obesity and related obesity in adulthood. This situation is alarmingly important as it is associated with many chronic diseases, especially the cardiovascular system.[12] However, it is known that participation in physical activity and positive sporting experiences in childhood and youth provide motivation for later ages and trigger the continuation of regular sports participation. The strong association between sports participation and body composition has been reported in many studies with different age groups.[13,14] In addition, in studies using different designs and methods to determine the relationship between sports participation and body composition (especially fat mass (FM)), it was reported that children and adolescents with high physical activity levels had lower FM[15-18] and Body Mass Index (BMI) values[19,20] were closer to ideal.

Another parameter considered important for health in children and adolescents is cardiorespiratory fitness.[21] Cardiorespiratory fitness is included in almost all child and adolescent fitness test batteries.[22] In children, improved cardiorespiratory fitness has been found to be associated with better cognitive function,[23] lower FM[24], and cardiovascular risk factors.[25] Although information on the prognostic aspects of low aerobic capacity in children and adolescents is not sufficient, there is evidence of an association with cardiovascular disease (CVD) risk.[26-28] CVD, which occurs as a consequence of low aerobic fitness in childhood, is likely to be observed in adulthood.[29] In some prospective studies in the literature, it has been determined that there is a negative relationship between improved aerobic fitness in adolescence and CVD in adulthood.[30,31]

In addition to the physical and physiological benefits of regular sports participation, it is also known to have positive effects on mental and psychosocial health. Taras[32] found that physical activity that increases blood circulation increases blood flow to the brain and increases noradrenaline and endorphin levels. Blakemore[33] stated that during physical activity, the brain is activated by increasing blood flow to the necessary areas that stimulate learning (stimulus) and that there are positive relationships between physical activity and memory, spatial perception, attention, understanding non-verbal cues, and decision-making ability. In studies conducted to determine the effect of sports participation on cognitive skills, it has been determined that lack of confidence and concentration,[34] positively affects mental skill levels such as attention, anxiety, self-confidence, and emotion regulation.[35-37]

It is known that the sedentary lifestyle, which has become widespread worldwide, negatively affects body composition, cardiovascular fitness[38], and cognitive skills[36] levels of children and adolescents. This situation negatively affects individual and social health and welfare. Although studies investigating the effects of children's and adolescents' participation in sports only at the physical or only at the cognitive level are frequently encountered, studies examining both together are rarely encountered. Therefore, this study aims to investigate the relationship between participation in sports club activities as an extracurricular activity and body composition, cardiovascular fitness, and cognitive level in boys aged 10-13 years. It is hypothesized that children who participate in extracurricular sports club activities have higher levels of body composition, cardiovascular fitness, and cognitive skills and that there is a positive relationship between body composition, cardiovascular fitness, and cognitive skills.

Materials and Methods

Study design and setting

This is a cross-sectional study investigating the relationship between participation in sports activities and cardiorespiratory fitness and selective attention and concentration performance in boys aged 10-13 years. In this study, a convenience sampling method was used. The study was conducted in two sports clubs in Uşak province (Uşak, Turkey). Participants were asked to fill in the questionnaire about their biographical information, leisure time sports activities, and d2 Attention Test. In addition, their height and weight were measured as anthropometric measurements, and they were asked to participate in an aerobic fitness test as physical performance. All measurements were made in February and March. Anthropometric and body composition data were first collected from the participants. Aerobic fitness was performed on an indoor court between 16.00 and 18.00 hours to avoid circadian effects. Participants were advised to refrain from physical activity 48 hours before the measurement to avoid strenuous exercise.

Study participants and sampling

Seventy-eight boys aged 10-13 years participated in the study. Participants were divided into sport and control groups based on the duration of sportive activities they participated in addition to school physical education classes. Forty-two participants who regularly participated in sportive activities for at least 1 year (at least 3 days a week) constituted the sports group (SG), while thirty-six participants who participated for less than 2 months constituted the control group [see Table 1]. In addition, boys who (i) did not use any medication affecting central nervous system function; (ii) did not use any medication, special diet, or smoking; and (iv) did not have any major illness or operation were included in the study. Children and their parents were verbally informed about the study before inclusion and questions were answered by the investigators. In addition, both participants and their parents signed the informed consent form. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Uşak University (code number: 144-144-21). G-Power analysis was used to calculate the sample size required to examine the effect of participation in out-of-school sports activities on students' physical activity, selected health-related fitness and d2 attention test levels and to reveal the possible relationship between variables. When this calculation was made, the effect size was 0.8 (large), the acceptable error level was ± 0.5% and the significance level was 95%. As a result of the analysis,

Table 1: Subject's age, anthropometrics, body composition, aerobic fitness, and cognition results, and group differences in percentage (%Dif.) (mean±SEM)

	All (*n*=78)	SG (*n*=42)	CG (*n*=36)	%Dif.
Age and anthropometry				
Age (year)	12±0.82	11.9±1.93	12.2±0.66	-2.6
Height (m)	149.9±8.48	149.5±9.4	150.3±7.37	-0.5
Body mass (kg)	42.1±10.2	38.9±7.18	45.8±11.9	-17.9*
BMI (kg/m^2)	18.6±3.38	17.4±2.48	20.1±3.73	-13.4*
Body Composition				
BF (%)	19.7±7.54	15.8±6.23	24.4±6.25	-54.1*
FFM (kg)	33.3±6.49	32.7±6.25	34±6.77	-4.06
Aerobic Performance				
Cardiorespiratory fitness (VO_2max)	31.1±6.73	36.6±3.29	24.8±3.12	32.3*
Cognitive Performance				
TN	374.2±88.5	394.2±96.9	350.8±71.8	11*
E1	45.7±46.2	48.3±51.5	42.7±39.6	11.6
E2	11.6±11.2	11.9±11.9	11.3±10.6	5.46
CP	120.4±43.3	131.1±42.6	107.8±41.1	17.7*

BMI: Body Mass Index; BF: Body Fat; FFM: Fat Free Mass; VO_2max=maximum oxygen uptake (ml/kg/min); TN: total number of items processed; E1: the number of mistakes due to omission; E2: errors of commission; CP: concentration performance. *Significant difference between two groups (P<0.05) it was concluded that at least 70 participants (n = 35 in each group) were needed for the study to be carried out.[39] More than the number of participants required for the realization of this study were provided for both the experimental and control groups.

Data collection tool and technique

Anthropometry and body composition

Both body mass and body composition were assessed by the bioelectrical impedance method using a Jawon body composition analyzer (model IOI-353). In this method, the device analyzes body composition based on differences in the ability of body tissues to conduct electric current (different resistance). All recommendations for bioelectrical impedance analysis were followed. The device was plugged in and calibrated to account for the weight of the garment (0.2 kg). Data on the subject's age, gender, and height were then entered. Participants then stood on the scale with their bare feet and hands on the marked places. Height was measured with a Mesitas portable height meter (Germany) and BMI was calculated using the formula "[BMI (kg/m^2) = body weight/($height)^2$].[40]

Cardiovascular fitness

To assess the cardiovascular fitness of the participants, Bangsbo *et al*.[42] described the standardized procedures of the YYIRT-1 test as follows. Participants were required to run between two lines drawn 20 meters apart in unison, with a beep that increased in frequency every minute. Participants are asked to slow down at the end of each shuttle and return to the start line within 10 seconds. If the participant is twice late to the finish line or fails to continue the run, the test ends, and the number of completed shuttles is noted. The estimated VO_2max was then calculated using the formula VO_2max = 36.4+ (0.0084 × distance traveled at YYIRT level 1).

Selective attention and concentration

In this study, the attention performance of the participants was evaluated with the d2 Attention Test, which is the version of the neuropsychological test developed by Brickenkamp and Cubero[41] to evaluate the sustained attention and visual scanning ability of the participants, and the validity and reliability study was conducted for Turkish athletes. On the front page of the test, there is a section where the participant's personal information and performance results will be recorded. There is also an exercise line to teach the participant the task. The back page contains the standardized test form. The test page consists of 14 lines with 47 marked letters in each line. Each line contains 16 different letters, consisting of the letters "p" and "d" with one, two, three, and four small signs. During the test, the participant has to scan the lines to find and cross out the letters "d" with two signs, ignoring the other letters that are not relevant. The subject is given 20 seconds for each line.

The scores obtained from the d2 Test and their meanings are given below.

Total number of items processed (TM): A quantitative measure of performance on all items processed, both relevant and non-relevant. A total number of items is highly reliable and is a normally distributed measure of allocation of attention (selective and sustained), processing speed, amount of work completed, and motivation.

Total error (H): Rank score errors (H) are the sum of all errors. The total error includes unmarked (H1) and incorrectly marked letters (H2). H1 occurs when the relevant items (letters d with two commas above or below them) are not marked.

Error percentage: Error percentage is a variable that measures the qualitative aspect of performance. It represents the proportion of errors made out of all items processed. As the error rate decreases, the accuracy of the subject, the quality of the work, and the degree of attentiveness increases.

Total items - errors (TM-H): TM-H is the total number of items scanned minus the error scores (H1 + H2).

Concentration performance (CP): CP is obtained by subtracting H2 from the number of relevant items (DM) marked correctly (d with two ds). In contrast to the TM-H, the new score of total performance (CP) is not distorted by tendencies to mark all letters indiscriminately or to skip random test sections. It is an excellent index of the accuracy of performance and coordination of speed. In the original study, this test showed a test-retest reliability higher than 0.90.

Data analysis

The IBM SPSS (version 23) analysis software was used to calculate the mean and standard deviation of each study value for total participants and according to participation in sports activities. Skewness and kurtosis values were examined to test the normality of the data, and it was determined that these values were within the range of -1.5 to + 1.5. An Independent sample *t*-test was performed to examine whether there was a significant difference between the groups in terms of body composition, cardiorespiratory fitness, and cognitive performance. Bivariate correlation coefficients were used to examine whether there was a significant relationship between body composition, cardiorespiratory fitness, and cognitive performance (TN, E1, E2 and CP). The significance level was set as $P < 0.05$.

Results

The subject's age, anthropometric, body composition, VO_2max, and TN, E1, E2, and CP scores derived from the d2 test are presented in Table 1. When comparing the boys active in sports clubs and non-active groups, both were similar in age, height, and FFM values ($P < 0.05$). However, the boys enrolled in a sports activity had lower body mass (-17.9%, $P < 0.05$ d = 0.72 [large effect]), BMI (-13.4%, $P < 0.05$, d = 0.87 [large effect]), and BF(%) (-54.1%, $P < 0.05$, d = 1.38 [large effect]). The boys active in sports clubs had 32.3% ($P < 0.05$, d = 3.67 [large effect]), higher VO_2max than the non-active group. The boys active in sports clubs also had better results in TN (11%, $P < 0.05$ d = 0.50 [medium effect]), and in CP (17.7%, $P < 0.05$ d = 0.56 [medium effect]) than the non-active group, while no differences were observed in the percentage of E1 and E2 scores between groups ($P > 0.05$).

Table 2 presents the bivariate correlation between the study variables. As seen in Table 2, VO_2max was negatively associated with body mass, BKI, and BF (r = -0.29, $P = 0.011$; r = -0.37, $P = 0.001$ and r = -0.62, $P = 0.00$, respectively). Regarding the selective attention and concentration, VO_2max showed a lower positive correlation with TN (r = 0.33; $P = 0.003$) and CP (r = 0.28; $P = 0.015$), whereas BF showed a lower negative correlation with TN (r = -0.28; $P = 0.012$) and CP (r = -0.28; $P = 0.012$) [Tables 1 and 2].

Discussion

This study shows that boys who participate in regular sports have lower body mass, BMI, and BF values. It was also determined that boys who participated in regular sports had higher levels of cardiovascular fitness and selective attention and concentration capacity compared to the control group. Other findings obtained from this study are as follows; (i) body mass and body fat percentage were negatively correlated with cardiovascular fitness (ii) lean muscle tissue was not correlated with cardiovascular fitness (iii) TN and CP from d2 test indices were positively correlated with cardiovascular fitness, (iv) d2 test indices TN and CP were not related to body mass, BMI and FFM, and (v) E1 and E2 indices were not related to all other parameters (body mass, BMI, BF, FFM and VO_2max).

Table 2: Bivariate correlation among the study variables

	Body Composition			
	Body mass	BKI	BF	FFM
VO_2max	-0.285*	-0.370*	-0.614*	-0.002
	Cognitive performance			
	TN	E1	E2	CP
VO_2max	0.329*	0.065	0.090	0.275*
Body Mass	-0.038	0.185	0.135	-0.098
BKI	-0.049	0.167	0.052	-0.131
BF	-0.0283*	0.025	0.014	-0.284*
FFM	0.104	0.212	0.169	0.026

BMI: Body Mass Index; BF: Body Fat; FFM: Fat Free Mass; VO_2max=maximum oxygen uptake (ml/kg/min); TN: total number of items processed; E1: the number of mistakes due to omission; E2: errors of commission; CP: concentration performance. *Significant correlation between variables ($P<0.05$)

These findings support the findings that sports participation improves body composition and cardiovascular fitness[43-45] and increases cognitive functions in boys.[46-48] In parallel with our results, these studies support the hypothesis that regular participation in sports leads to improved physical fitness, which in turn positively affects cognitive functions. The prevailing view in the literature on the link between physical activity and cognitive abilities is that continuous participation in physical activities positively affects brain structure and executive functions, leading to improved cognitive abilities and academic performance in children and adolescents. However, more experimental studies using short- or long-term physical exercise interventions are needed to clarify the causal effects between physical activity and cognitive functioning.[48]

This study found a positive association between higher selective attention and concentration capacity and improved cardiorespiratory fitness. In general, the literature supports this result and reports that childhood cardiorespiratory fitness is associated with higher selective attention and concentration capacity.[46,49-52] On 370 boys and 319 girls with a mean age of 9.61 years, a moderate-high (-0.075) correlation between cardiorespiratory fitness and concentration performance was reported. Similarly, Paez-Maldonado *et al.*[53] reported a positive association between higher fitness values and selective attention and concentration capacity in a recent study in boys and girls of similar age to our study. It is known that the effects and relationships found in these studies are due to cardiorespiratory fitness, which is a subcomponent of physical fitness. Garcia- Hermoso *et al.*[41] suggested that an 8-week physical activity program implemented in preschool supported the improvement in cardiorespiratory fitness and selective attention and concentration capacity in children. However, there are also studies in the literature reporting that the beneficial effect of cardiorespiratory fitness on cognitive functioning remains unclear, especially in children,[50] and that improved cardiorespiratory fitness does not appear to be the mechanism that provides the cognitive benefits of exercise.[52] Mokgothu and Gallagher[53] reported that there was no relationship between aerobic fitness and attention, memory, and decision-making skills in 47 boys aged 12-14 years, unlike adults. Our results support recent studies reporting that cardiorespiratory fitness is associated with higher selective attention and concentration capacity. The reported positive effects of aerobic activities on mental health and its reported role as a powerful stimulus for cerebral structural changes.[54] and the association of improved cardiorespiratory fitness with improved brain function[55,56] may be shown as explanatory factors for this relationship.

Another result of the study shows that boys who participate in regular sports activities have lower body mass and body fat percentage values and body fat percentage has a low negative relationship with selective attention and concentration capacity. Our study findings showed similar results with previous studies[49,57-59] conducted in children and adolescents. García-Hermoso[49] and Cadenas-Sanchez[59] reported a negative relationship between fat mass and Fat mass index (FMI) and selective attention and concentration capacity (d2 test). Similarly, Davis ve Cooper[57] found a negative association between body fat percentage and attention ability obtained from The Cognitive Assessment System in healthy overweight 7-11-year-old children. In parallel with the findings of this study, recent studies show that obesity in childhood and adolescence is associated with deficits in brain structure and cognitive skills.[60-62] In this negative relationship, it is stated that excessive weight gain is associated with cognitive abnormalities in children as well as changes in brain structure such as gray matter volume, white matter integrity, and cortical thickness.[62] Recent studies have reported that increased BMI values are associated with a thinner cortex in various regions of the brain, especially in the prefrontal cortex, an area related to executive function.[61]

Another finding from this study is that there is a negative relationship between cardiorespiratory fitness and body mass, BMI, and BF. In particular, body fat percentage and cardiorespiratory fitness are often evaluated in relation to each other, and the consensus is that these parameters are strongly negatively correlated with each other. In studies conducted in different countries, these correlations have been demonstrated according to gender and age.[63-67] These studies reported that increases in body fat percentage and BMI lead to a decrease in cardiorespiratory fitness in children and adolescents, which supports our study findings. In a recent cross-sectional studies by Castro *et al.*[68] and Mondal and Mishra[69] in preadolescent children, they reported that cardiorespiratory fitness was strongly associated with all indicators of adiposity, body fat percentage, fat mass, BMI, and waist to hip ratio, with a non-linear relationship between body fat (%) and VO_2max. Similarly found high correlations between aerobic fitness and body fat percentage in both girls and boys aged 11-14 years. Minasian *et al.*[66] found high correlations between aerobic fitness and body fat percentage in both girls and boys aged 11-14 years. Heroux[63] reported negative correlations between cardiorespiratory fitness and body composition measures in Canadian, Mexican, and Kenyan children aged 9-13 years, independent of country and gender. In addition to these, although rare, there are studies reporting a relationship between FFM and cardiorespiratory fitness, contrary to our study findings.[65,67]

This study has several potential limitations that should be considered before contextualizing the results. First, this was a cross-sectional study, whereas further longitudinal research is needed to better determine potential causal relationships between activity behaviors. Second, other specific cognitive abilities that constitute executive functions are missing. Third, this study was conducted with fourth-grade children and therefore the results cannot be generalized to other population subgroups. Nevertheless, this study contributes to our understanding of both the relationship and the dose of PA required to improve academic achievement through the moderating role of cardiorespiratory fitness.

Conclusion

In conclusion, this study revealed that boys who participated in out-of-school sports activities had improved body composition, cardiorespiratory fitness, and selective attention and concentration capacity compared to their peers who did not participate in any sports activity. Our findings also suggest that increases in body fat percentage and BMI and impairments in cardiorespiratory fitness negatively affect selective attention and concentration capacity. Childhood is an important period not only for brain and cognitive development but also for the acquisition of lifelong physical activity habits in terms of health, fitness, and physical fitness. For these reasons, taking measures to improve health-related physical fitness and promote healthy living, especially in inactive children and young people, is an issue that should be considered by governments, schools, sports organizations, health and exercise professionals, and parents. Considering the increasing prevalence of obesity in children and adolescents due to sedentary living, which has become a worldwide epidemic, it is recommended that the relationships between body composition, cardiorespiratory fitness, and cognitive abilities should be considered from a public health perspective.

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Conflicts of interest
There are no conflicts of interest.

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