Environ Health Prev Med (2016) 21:27–33
DOI 10.1007/s12199-015-0495-x

REGULAR ARTICLE

Association between academic achievement and physical status including physical activity, aerobic and muscular fitness tests in adolescent boys

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Received: 6 July 2015 / Accepted: 29 September 2015 / Published online: 22 October 2015

Abstract
Objective The study aimed to explore the association between academic achievement and physical status including physical activity, aerobic and muscular fitness tests in a sample of adolescents.
Methods Five hundred and eighty 15–17 years old adolescent boys underwent standard anthropometry and various physical fitness tests (e.g., one-mile run/walk, grip strength, run speed, agility, push-ups and sit and reach tests). PA was obtained by questionnaire. Academic achievement of the boys was extracted from the cumulative grade point averages (CGPA) from school records. Possible covariates/confounders such as adiposity, pubertal maturation status and socioeconomic status were obtained.
Results After controlling for potential confounders PA was not significantly correlated to CGPA ($P > 0.05$). Among the physical fitness tests, just time in one-mile run/walk test added significant effect on prediction of CGPA ($P < 0.01$). None of the other fitness tests were significantly correlated to CGPA ($P > 0.05$).
Conclusions Aerobic fitness (but not PA and muscular fitness) was significantly correlated to better academic achievement in the adolescent boys.

Keywords Adolescent boys · Cumulative grade point averages · Muscular fitness · One-mile run/walk test

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Abbreviations

BMI	Body mass index
CRF	Cardiorespiratory fitness
CGPA	Cumulative grade point average
PA	Physical activity
PAQ-A	PA Questionnaire-Adolescents
SES	Socioeconomic status

Introduction

Inactivity is a growing public health and educational concern. Children and adolescents have become increasingly sedentary, and this lifestyle change is associated with substantial increases in obesity [1], and several metabolic diseases [2]. A sedentary lifestyle during childhood not only influences physical health, but cognitive and brain health as well [3], and it has been suggested that low levels of physical activity (PA) and aerobic fitness are associated with declines in cognitive abilities, brain structure and function, and academic achievement [3].

While reviewing the literature, underlying relationship between academic achievement and PA it is observed that some studies reported significant positive relationship between them [4–6], but some other studies reported no relationship or even negative relationship [7–12].

On the other hand, there is a possibility that maintaining a high level of physical fitness may be helpful for improving academic achievement [5].

However, physical fitness consisted of various components. For example, cardiorespiratory fitness (CRF) and muscular fitness (e.g., strength, speed, flexibility, agility, etc.) are components of physical fitness that have

documented potential to improve health and each of which may have different effects on the brain and, therefore, academic performance [13]; therefore, it is important to differentiate which physical fitness components are important in relation to academic achievement, while some previous studies summed the number of fitness tests that youth passed [14–16] and among the other little studies based on the relationship between muscular fitness and academic achievement, inconsistency results are existed, which some reported no significant relationship [17–19], but some reported significant relationship [13].

Furthermore, little studies have been conducted underlying relationship between academic achievement, PA and physical fitness on Asian children and adolescents [18, 20] while the cultural differences may affect this fitness-academic performance relationship [18, 21].

The present study aimed to explore association between academic achievement and physical status including physical activity, aerobic and muscular fitness tests in a relatively large sample of adolescents.

Methods

Participants and procedure

During 2014–2015, a cross-sectional data were drawn from a sample of five hundred and eighty 15–17 years old adolescent boys. Four schools were selected randomly from a list of boys' urban public high schools (total number = 52) in the center of Ardabil Province, North West of the Iran. At the second stage classes in each school were selected randomly and adolescents of the selected classes (30 classes, total number = 757) were invited to the study. Exclusion criteria were as follows: known presence of chronic disease and musculoskeletal injury that prevent the adolescents from performing the fitness tests. Adolescents who were invited and passed the exclusion criteria of the study and gave their consent verbally ($n = 649$) were given a written consent form for their parents approval. 621 signed consent forms were collected and the owners were recruited in the study. However, at the end of the study, complete data were collected from 580 participants (dropped data because of absence, illness, withdrawal of the study for some personal reasons, etc.). Age of the participants was determined from their date of birth in their school register. All measurements were carried out during regularly scheduled physical education lessons. Measuring of anthropometric variables was done in the empty room, when the participants were at rest. The physical fitness tests that adolescents underwent were carried out outdoor. All measurements were done during the fall–spring (9 months) of the year 2014–2015. The present study was approved by the Human Ethics Committee of the Ardabil department of Education, and the experiment was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. All the adolescents volunteered for the present study and Informed consents according to the rules of the department were acquired from all the participants in written and parents' signed form.

Academic achievement

In terms of academic achievement, the study followed the rules of the Ministry of Education in Iran, in which the cumulative grade point averages (CGPA) were recorded from the school record of the previous semester (middle of the current year) and end of the current year and divided to 2 for obtaining mean CGPA of the year. Promotion through the Iranian education system is based on end-of-year examinations at primary, intermediate, and secondary cycles, and end-of-term examinations (sometimes both middle- and end-of-term examinations) at post-secondary cycle. At intermediate, and secondary schools, system of grading is based on a 0–20 scale. An average scale of at least 10 is required for promotion. The letter grade equivalents are: A = 17–20; B = 14–16.9; C = 12–13.9; D = 10–11.9; therefore, high score indicates higher academic achievement [you may refer to: 22, 23].

Aerobic and muscular fitness

The adolescents underwent six physical fitness tests according to standard methods [24–28]. In the present study, one-mile run/walk test was used for measuring aerobic fitness; while rest of the tests were used for measuring muscular fitness.

1. One-mile walk/run test: this test was used to assess aerobic fitness. The objective of the one-mile run/walk test was to cover a mile in the shortest time possible. The adolescents were encouraged to run throughout the test and to take walking breaks only as needed. The adolescents also were reminded to avoid starting too fast to avoid premature fatigue. Performance in the one-mile run/walk test has been correlated with VO_2max and validated [28].
2. Sit and reach: participants sat on the ground with straight legs against a standard reach box with 23 cm marked at the level of the feet. They were instructed to reach smoothly forward and sustain in the extreme reach position for 2 s. This test measures the flexibility of the hamstrings, buttocks, and lower back [26].

3. Hand grip strength test: this test was used to assess static strength. It was done by squeezing a calibrated digital hand dynamometer (Takei) as forcefully as possible with the both hands [26]. The test was performed twice, and the maximum score for each hand was recorded in kilograms. The average score of the left and right hands was calculated.
4. 40-m sprint (from standing position): this test was used for measuring speed of movement.
5. Push-ups: Timed push-ups test (60 s) with extended legs was used. This test measures upper arm and shoulder girdle strength/endurance [28].
6. Illinois agility test: completing a weaving running course in the shortest possible time. Cones mark the course; the subject starts face down, with the head to the start line, and hands by the shoulders. At the whistle, the adolescents run the course, without knocking down any cones. The purpose of this test is to measure the subject's speed and agility [27].

The agility, run speed and sit and reach tests were performed twice, and the fastest time or better performance was recorded. A handheld stop-watch was used for recording time to the nearest 0.01 s (Joerex, ST4610-2, China).

Physical activity (PA)

PA for adolescents was measured using the PA Questionnaire-Adolescents (PAQ-A) [29] with some alternations according to our society [30]. For example, some sports and games (such as baseball, softball, rowing or canoeing, ice hockey or ringette, cross-country skiing, ice skating) were exchanged with some local games. The PAQ-A is used to assess the PA behaviors of the participants at different times and places (i.e., during school, after school, recess, weekend, etc.) during the previous 7 days. Scoring is based on a 5-point Likert type scale, with an overall PA score derived from the mean of each scored item. Higher levels of PA are indicated by greater scores and vice versa. The PAQ-A has been tested and re-tested, and results have indicated that the questionnaire is reliable and valid measure of PA for adolescents during the school year [29, 31]. This questionnaire is widely used in research, in order to assess PA of large and small populations at low cost [32].

Possible confounders/covariates

In the present study, possible covariates such as age, adiposity [12, 33, 34], pubertal maturation status and socioeconomic status [35–38] were obtained as follows:

Anthropometric variables

Weight was measured in underwear and without shoes with an electronic scale (Type SECA 861) to the nearest 0.1 kg, and height was measured barefoot in the Frankfurt horizontal plane with a telescopic height measuring instrument (Type SECA 225) to the nearest 1 mm.

Subcutaneous fat percentage was measured as a reliable overall obesity index than body mass index (BMI) in the adolescents [39, 40]. Lange skinfold calipers were used to assess triceps (vertical fat fold taken midway between the olecranon process and acromion process on the posterior aspect of the arm) and calf (vertical skinfold taken on the medial aspect of the calf at the point of largest circumference) skinfold thickness [41]. All measurements were taken on the right side of the body. The average of three measures was calculated for each site and the following equation was used to predict percent fat [41]:

$$\text{Adolescent boys } \% \text{ fat} = 0.735\,(\text{sum of average skinfolds}) + 1.0$$

Pubertal maturation status (PMS)

Adolescents were asked to classify themselves in one of the five stages of PMS defined by Tanner and Whitehouse [42]. This standard staging describes genital and pubic hair development in boys. The first Tanner stage corresponds to the prepubertal state; subjects classified in Tanner Stage 5 are completely mature.

Socioeconomic status (SES)

SES was computed from parents' education and occupational status. Monthly household income was collected in the following Iranian Rial categories (note 1$USD equals approximately to 34000 Rial in Iran): 1 = <4000000 Rial; 2 = 4000000–8000000 Rial; 3 = 8000000–12000000 Rial; 4 = 12000000–16000000 Rial; 5 = 16000000–20000000 Rial; 6 = 20000000–25000000 Rial; 7 = 25000000–30000000 Rial; 8 = 30000000–40000000 Rial; 9 = 40000000–50000000 Rial; 10 = >50000000 Rial.

The highest educational level attained by either parent was collapsed into the following categories: 0 = no education; 1 = elementary; 2 = secondary 3 = some high school 4 = completed high school; 5 = bachelor degree 6 = Master of Science/Arts; 7 = PhD, Doctoral, etc.

In cases where SES scores were available for both parents, the mean was used. Self-administered questionnaire which was answered by the adolescents' parents was used for obtaining parents' education and occupational status.

Data analysis

Descriptive statistics were run on all variables. Before further analysis, all data were checked for normality by Kolmogrove–Smirnove test, and appropriate transformations using natural logarithm (transformation by exponential value) were applied when necessary (e.g. PA score, grip strength, sit and reach and push-ups tests were transformed). Because all the adolescents reported themselves in the stage V of the PMS category (except 15 ones who reported themselves in stage IV of the PMS category), we excluded PMS in the analyses. Initial Pearson product–moment correlations were conducted on CGPA, demographic variables (age and SES), adiposity, PA score and the physical fitness variables. Any variable exhibiting a significant correlation with the dependent variable (CGPA) was included as a covariate/confounder in the multiple linear regression analyses. Hierarchical linear regression analyses were conducted as follows: age, SES and % fat (significant covariates; according to the results of Table 2) were included in the first step of the regression analyses. The physical fitness variables were added into the second step of the analysis, separately. Although PA was not significantly correlated to CGPA (see Table 2), because of its significant effect on physical fitness, it was included in the second step, when its significant correlation with a fitness test was observed. All calculations were performed using SPSS v.21.0 software for Windows. The significance level was set at $P < 0.05$.

Results

General characteristics of the participants are shown in the Table 1.

Results of Pearson product–moment correlations (Table 2) indicated significant positive relationship between CGPA, age ($P < 0.01$) and SES ($P < 0.05$); but negative relationship was observed between CGPA, fat%, BMI, one-mile run/walk, grip strength, run speed and agility ($P < 0.01$). PA was significantly and negatively correlated to the one-mile run/walk and run speed tests ($P < 0.01$) and positively correlated to the sit and reach and push-ups tests ($P < 0.01$).

Multiple regression analysis (Table 3) revealed significant relationship between CGPA, age, SES and fat% (step 1; $P < 0.05$). PA was not significantly correlated to CGPA in all the second steps ($P > 0.05$). Among the physical fitness variables, just introducing time in the one-mile run/walk exhibited significant effect on the model (step 3; F change $= 5.71$, $P < 0.01$) and was significantly correlated to CGPA (standardized $\beta = -0.19$; $P < 0.01$). None of the other fitness tests were significantly correlated to CGPA and introducing them to the model indicated no significant effect on prediction of CGPA in the adolescent boys ($P > 0.05$).

Table 1 Characteristics of the adolescent boys ($n = 580$)

	Mean (SD)
Age (years)	15.7 (0.7)
Height (cm)	168.0 (8.1)
Weight (kg)	58.6 (13.1)
% Fat	22.4 (10.3)
BMI	20.7 (3.9)
CGPA (score)	15.3 (2.3)
PA (score)	2.7 (1.7)
One-mile run/walk (s)	589.6 (107.6)
Grip strength (kg)	43.9 (10.1)
40-m run speed (s)	6.5 (0.7)
Illinois agility (s)	17.7 (1.6)
Sit and reach (cm)	25.6 (8.5)
Push-ups (n)	18.9 (10.4)

BMI body mass index, *PA* physical activity, *CGPA* cumulative grade point average

Discussion

In the present study, no significant relationship was observed between academic achievement and PA in the adolescents. Reviewing the literature, some studies have shown positive relationships between academic achievement and both PA [5, 6] and sports participation [4]; whereas some have shown no correlation [8] or an inverse relationship [11, 12]. Some recent studies using objectively measured PA reported no or negative relationship between academic performance and PA among children and adolescents and reported that the relationship between academic performance and PA needs to be examined by longitudinal studies [7, 9, 10]. It is possible that the students with higher PA levels spend lower time for their academic works. However, for clarifying the subject future longitudinal studies are needed to delineate the relationship.

The results revealed that among the measured fitness tests and after adjustment for possible covariates aerobic fitness was significantly correlated to academic achievement in the adolescents. However, no significant relationship was observed between academic achievement and rest of the fitness tests in the adolescent boys. Grissom [15] examined the relationship of physical fitness (shuttle run, push-ups, sit-ups, and sit and reach) to academic performance in a sample of students. His findings revealed a positive relationship between fitness and academic

Table 2 Pearson correlation among the study variables

	2	3	4	5	6	7	8	9	10	11	12
1. CGPA	0.14**	0.12*	−0.17**	−0.20**	0.05	−0.20**	−0.13**	−0.15**	−0.17**	0.09	0.03
2. Age		0.09	−0.06	−0.03	−0.07	−0.08	0.15**	−0.22**	−0.29**	0.09	0.07
3. SES			0.03	−0.02	0.07	0.07	0.04	−0.11*	−0.15**	−0.05	0.11*
4. %Fat				0.87**	−0.24**	0.49**	0.11*	0.54**	0.32**	−0.25**	−0.37**
5. BMI					−0.21**	0.48**	0.26**	0.37**	0.31**	−0.15**	−0.29**
6. PA						−0.29**	−0.07	−0.20**	−0.01	0.21**	0.27**
7. One-mile run							−0.01	0.37**	0.37**	−0.27**	−0.48**
8. Grip strength								−0.31**	−0.16**	0.10*	0.28**
9. Run speed									0.54**	−0.33**	−0.49**
10. Agility										−0.20**	−0.34**
11. Sit and reach											0.35**
12. Push-ups											

* Significant at <0.05; ** significant at <0.01

Table 3 Hierarchical regression analysis between CGPA, PA and the physical fitness variables after adjustment for possible covariates

	CGPA				
	Tolerance	Standardized β (P)	R^2	F change	Adj. R^2
Step 1			0.04	5.40**	0.035
Age	0.98	0.10 (0.04)			
SES	0.99	0.11 (0.04)			
%Fat	0.99	−0.13 (0.01)			
Step 2			0.07	5.71**	0.06
Age	0.97	0.09 (0.07)			
SES	0.98	0.13 (0.02)			
%Fat	0.72	−0.03 (0.41)			
PA	0.84	−0.07 (0.42)			
One-mile run/walk	0.72	−0.19 (<0.01)			
Step 2			0.05	0.77	0.040
Age	0.92	0.11 (0.04)			
SES	0.97	0.11 (0.04)			
%Fat	0.68	−0.09 (0.15)			
PA	0.86	−0.04 (0.72)			
Run speed	0.67	−0.07 (0.34)			
Step 2			0.06	2.80	0.05
Age	0.92	0.06 (0.29)			
SES	0.97	0.14 (0.01)			
%Fat	0.92	−0.10 (0.07)			
Agility	0.84	−0.10 (0.09)			
Step 2			0.055	3.60	0.045
Age	0.96	0.13 (0.01)			
SES	0.99	0.11 (0.03)			
%Fat	0.98	−0.11 (0.04)			
Grip strength	0.97	−0.10 (0.07)			

* Significant at <0.05; ** significant at <0.01

performance. Castelli et al. [17] extended the findings of the Grissom's study [15] through the examination of younger children and various fitness tests (PACER test, push-ups, sit-ups, sit and reach) and the results corroborated the findings of the Grissom [15]. However, when the individual components of the fitness tests were examined, it

was determined that only aerobic capacity was significantly related to achievement test performance [17]. Consistent with Castelli et al. [17] some other recent studies reported significant relationship between CRF (but not muscular fitness) and academic performance, which are in accordance with our results [18, 19]; however, some other recent studies reported that both CRF and muscular fitness were significantly related to academic performance [13], and it seems that the relationship between muscular fitness and academic achievement needs to be clarified by more studies. Greater CRF has been reported with induced angiogenesis in the motor cortex and increased blood flow, and therefore, improved brain vascularization which could affect cognitive performance [43]. In addition CRF has been positively reported with changes in neurocognitive function [44], more effective neuroelectric profile and better behavioral measures of reaction time and response accuracy, changes in the structure and function of brain tissue in elderly adults and preadolescents [45, 46]. Overall, it has been suggested that childhood CRF is associated with higher levels of cognition and differences in regional brain structure and function [3].

The present study results indicated significant positive relationship between academic achievement and SES in the adolescents, which is consistent with the literature [35, 37]. SES is strongly associated with cognitive ability and achievement during childhood and beyond [38]. For instance, low SES affects student's outcomes because low SES prevents access to vital resources and creates additional stress at home [35–37].

The results indicated significant negative relationship between academic achievement and adiposity in the adolescents. The present study results are consistent with several studies that indicated adolescents at risk of obesity typically earn lower grades, and individuals who were obese, complete significantly fewer years of schooling than do their non-obese peers [12, 33, 34]. However, some studies found no significant relationship between obesity and academic achievement among children and adolescents [10, 47]. Discrepancies among the studies may, in part, be due to differences in methodology. Both adiposity and academic achievement measures varied widely across studies. Cultural differences may also play a role, too [12]. For instance, in the previous study [25] we observed lower CGPA for the overweight/obese adolescent boys than their underweight/normal weight peers and CGPA was decreased as adiposity increased; but significant difference was observed just between obese adolescents and their underweight counterparts. However, after controlling for additional confounders (e.g. SES and sedentary behavior) the significant difference was disappeared. The observed difference between the studies (present vs. previous) may be methodological differences such as covariates used in the studies, obesity indices were used in the previous and the present study (BMI vs. fat%; respectively), statistical analyses (continuous vs. comparison statistics) and samples being studied.

Although the strengths of the present study are its sample size, considering various variables and potential confounders; nonetheless, since the study has several limitations, results need to be interpreted with caution. For example, the cross-sectional nature of the study limits the possibility to draw conclusions about causality of any of the observed relationships. Lacing subjects of both sexes was the second limitation. The third limitation of the study was using questionnaire for obtaining PA [29], while, objective measure of PA such as accelerometry could produce much more reliable results.

Acknowledgments We thank all participants for their kind participation in the study. No funding was received for performing the present study.

Compliance with ethical standards

Conflict of interest The author has no conflicts of interest to declare.

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