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ORIGINAL ARTICLE

Health-related Fitness Assessment in Greek Schoolchildren 12-16 Years Old

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Abstract

The present study evaluated the influence of age and sex on the level of health-related fitness components in secondary school students. The participants were 330 secondary schoolchildren (158 boys and 172 girls) 12-16 years old. For the evaluation of health-related fitness (aerobic capacity, muscular strength and endurance, flexibility and body composition), the Fitnessgram test battery was used. Results revealed significant differences for age and sex for the one mile run-walk test, for the curl up test and for VO_{2max}. Also, there was significant main effect of age on body mass index and the trunk lift test. Moreover, there was a significant main effect of sex on back saver sit and reach test, while no significant differences were found between age and sex in the push-up test. The students succeed in achieving the criteria, which were in the "Healthy Fitness Zone", as these indicated by the Fitnessgram test battery, in a percentage more than 97% for the curl up test, 88% for the trunk lift test, 78% for the back saver sit and reach test, 72% for the 90^o push-up test . In contrary, the students were in the zone "Need Improvement" in a percentage of 39% for the one mile run-walk test, 20% for the VO_{2max} and 25% for the Body Mass Index. A better understanding of the individual differences that exist in different ages and between boys and girls, could have strong implication for planning and teaching physical education in schools aiming to increase students' fitness level.

Keywords: *Adolescence, cardiovascular disease, exercise, Fitnessgram test, risk factors, aerobic capacity*

Introduction

Measuring physical fitness in young and adolescence has been a topic of interest for physical educators, health scientists and organizations dealing with sports, fitness and health. Numerous fitness tests have been constructed by physical educators, exercise physiologists and sports trainers during the last 50 years. There is strong and consistent evidence from observational studies that low levels of fitness are associated with high risk of cardiovascular disease and all-cause mortality, and improvements in fitness are associated with reduced mortality risk (Mora et al. 2003).

Also, cardiorespiratory fitness in children and adolescents, is inversely associated with risk factors for chronic diseases that include high blood pressure (Carnethon et al. 2003), hyperinsulinemia (Gutin et al. 2004), fat mass (Ball et al. 2004), insulin resistance (Kasa-Vubu et al. 2005) and metabolic risk factor (Brage et al. 2004). Other fitness components, such as muscle strength and endurance, flexibility and body composition are related to health, particularly in pediatric populations as Bar-Or and Malina (1995) have mentioned. According to Simons-Morton et al. (1988) the development of positive attitudes toward physical fitness during childhood may affect the level of fitness during adulthood. Also, fitness and fatness have been found to track over lifespan; therefore it is important for children to establish positive lifestyle attitudes and acceptable levels of fitness at an early age (Yang et al. 2006).

During the 1990s the interest was focused on children's health-related fitness levels and several authors implemented successfully different physical education models for health-

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related fitness enhancement. If exercise during childhood can increase the likelihood that a person will be physical active through adulthood, significant health benefits are possible (Paffenbarger et al. 1986). Most published studies have used only cardiorespiratory fitness as a fitness measure based on sampled subjects in a research setting. Despite the lack of consensus on criterion measures of physical fitness, accepted health-related fitness measures must include cardiorespiratory endurance, muscular strength and endurance, flexibility, and body composition (The Cooper Institute, 1999). Physical fitness testing for schoolchildren is a common component of physical education programs for 30 years. Fitness testing methods have changed dramatically, most of them now emphasizing on components of health related fitness that are important across life span. Even if there are some differences among testing procedures, clearly all emphasize on evaluation of the health related fitness components. This represents a major change from the situation 10 to 20 years ago, reflecting a heightened appreciation for the role that exercise and fitness can play in promoting health and preventing disease. Fitnessgram is a complete battery of health-related fitness items that are scored using criterion-referenced standards. These standards are age and gender specific and are established based on how children need to be fit for optimal health. Fitnessgram test battery includes a variety of health related physical fitness tests, designed to assess cardiovascular fitness, body composition, muscle strength, muscular endurance, and flexibility (The Cooper Institute, 2004).

Maximum oxygen consumption (VO_{2max}) estimates the aerobic fitness that plays an important role in the development of obesity due to its significant association with physical activity in young children. Aerobic fitness is a marker of later cardiovascular disease (CVD), with greater aerobic fitness being associated to a reduction in risk of later CVD (Young et al. 1995). Resistance training has been accepted for long as a mean for developing and maintaining muscular strength, endurance, power and muscle mass. It's beneficial relationship to health factors and chronic diseases has been recognized relatively only recently (Pollock and Evans, 1999).

Prior to 1990, resistance training was not a part of the recommended guidelines for exercise training and rehabilitation for either the American Heart Association or the American College of Sports Medicine (ACSM). In 1990, the ACSM first recognized resistance training as a significant component of a comprehensive fitness program for healthy adults of all ages (American College of Sports Medicine, 1990).

Body composition refers to the components that make up body weight. The major contributors to body weight are the muscles, bones, and fat content. The average reference fat content of the body is 15% for boys and 25% for girls. Research has shown that childhood obesity has increased by 3 times in most industrialized countries over the last 20 years and these trends have major public health consequences (Ebbeling et al. 2002). It has been found (Freedman et al. 1999) that overweight or obese children and adolescents have adverse lipid profile, blood pressure and insulin levels and are more likely to become obese adults than non overweight or obese children.

The limited research on this topic in Greece and the limited data available on the fitness level of Greek children was the criterion for the present study in an attempt to search the effect of age and sex on health-related fitness components in secondary school children according to the Fitnessgram test battery standards.

Methods

Participants

The sample was constituted by 330 students and 158 of them were boys and 172 girls. The age of the participants varied between 12-16 years and they were attending classes in seven different public secondary schools. The chosen schools were in rural and urban settings in the prefecture of Larissa, central Greece. Inclusion participant's criteria were not to be trained systematically in any form of training program, no mental or physical handicap, no chronic diseases such as diabetes or moderate to severe asthma, all identified by parents or teachers.

Measurements and Procedures

Anthropometric measurements

The height was measured to the nearest 0,5 cm while the students were standing barefoot with their backs to a wall-mounted stadiometer. The students' weight was measured to the nearest 0,5 kg with calibrated scales, wearing light clothing. Age at baseline was computed from the reported birth date.

Body mass index (BMI)

It was calculated as weight (kg) divided by height squared (m2). The cut off points for BMI are computed according to the Cole at al. (2000) norms.

VO2max

Aerobic capacity as a measure of aerobic fitness was predicted from one mile run/walk time, age, gender and BMI, using the Cureton equation (1995).

Physical fitness

Brief descriptions of the fitnessgram tests were used as follow:

One-mile run/walk

This test measures cardio-respiratory endurance. The objective is to walk or run a mile distance at the fastest pace possible.

90o push up

This test measures the upper body muscular strength and muscular endurance (muscle fitness). Push-ups are done in a slow rhythmical pattern, with arms lowered to ninety-degree angles, with the back and legs straight. Girls executed the push up test using their knees to support the body. The test objective is to complete as many push-ups as possible at a rhythmic pace.

Back saver sit and reach (BSSR)

This test measures the joint flexibility, which is important for functional health. The test objective is to reach the specified distance on the right and left sides of the body.

Trunk lift

This test measures low back muscular strength and flexibility. The test objective is to lift the upper body off the floor using the muscles of the back and hold the position to allow for the measurement

Curl up

This test measures the abdominal strength and endurance. The objective of this test is to complete as many curl-ups as possible.

The Standards

Fitnessgram uses criterion-referenced standards to evaluate the fitness performance. These standards were established by the Cooper Institute for Aerobic Research to represent a level of fitness that offers some degree of protection against diseases that result from sedentary living. Performance is classified into two general areas: "in the healthy fitness zone (HFZ)" and "needs improvement". All students should strive to achieve a score within the HFZ. It is possible that some students score above the HFZ.

Statistical Analysis

All statistical analyses were carried out using the SPSS software v. 10.0 for Windows (SPSS Inc., Chicago, IL) package for personal computers. Differences per age and sex among each of the six dependent variables (one mile run-walk test, 90o push-up test, curl-up test, back saver sit and reach test, trunk lift test, BMI and VO2max) were examined using two-way ANOVA. For all statistical comparisons, a significance level of P= 0.05 was chosen.

Results

The number of students within each age and sex group are shown in Table 1, while descriptive statistics for the total sample and by gender for all the tests of the Fitnessgram test battery are shown in Table 2.

Table 1. Participants by gender and age.

	12 years		13 years		14 years		15 years		16 years	
	No	%	No	%	No	%	No	%	No	%
Females	(48)	53,93	(45)	54,88	(45)	47,37	(22)	51,16	(12)	57,14
Males	(41)	46,07	(37)	45,12	(50)	52,63	(21)	48,84	(9)	42,86

Table 2. Performance scores per age and sex on the components of health – related fitness.

		12 yrs- M±SD	13 yrs- M±SD	14 yrs- M±SD	15 yrs- M±SD	16 yrs- M±SD
1 mile run walk (min.)	boys	9,12±1,93	9,30±2,21	9,19±2,27	7,57±0,95	7,63±0,97
	girls	11,71±2,57	11,72±1,68	11,02±1,94	10,14±1,16	9,95±0,87
90^o push up (rep.)	boys	14,90±5,60	15,81±8,68	11,87±8,44	12,61±7,73	11,50±6,70
	girls	13,54±7,85	10,22±8,23	11,83±7,58	15,11±4,94	18,02±3,96
Curl up (rep.)	boys	65,57±19,09	53,38±14,61	55,35±16,68	58,24±5,39	56,86±7,21
	girls	44,67±17,18	35,11±10,86	35,25±13,39	37,50±6,08	36,10±5,62
Back saver sit & reach (cm)	boys	20,15±8,54	24,00±9,94	23,32±6,60	23,10±4,10	21,56±7,33
	girls	24,42±5,97	26,27±8,53	25,87±6,69	26,05±3,17	26,83±3,54
Trunk lift (cm)	boys	33,29±6,96	27,30±9,16	31,58±6,17	27,62±4,58	31,00±5,98
	girls	34,54±6,17	33,51±6,37	32,00±4,66	28,32±3,33	29,67±5,02
$V0_{2max}$ (ml/kg/min)	boys	47,39± 5,41	46,17±5,73	45,87±6,54	48,45±6,77	47,71±5,83
	girls	41,73±3,85	38,49±3,71	40,51±3,62	40,51±3,90	40,32±3,34
BMI (kg/m^2)	boys	20,12±2,96	21,79±3,52	22,81±4,19	23,52±5,67	24,4±4,16
	girls	20,89±4,24	23,24±4,24	21,78±3,48	22,08±3,72	22,42±3,26

In Table 3 overall results are reported in two ways. First, the percentage of students in healthy fitness zone (HFZ) for each fitness task is presented. A student not in the healthy fitness zone indicates that the student has not met the minimum level of fitness for that fitness task. As this section of the table shows, for most of the fitness tasks a significant percentage of students do not meet the minimum levels.

Table 3. Percentage of the students belonged (or not) in the HFZ in physical fitness tests by age.

Physical Fitness Tests	12 years		13 years		14 years		15 years		16 years	
	% in HFZ*	% Not in HFZ*	% in HFZ*	% Not in HFZ*	% in HFZ*	% Not in HFZ*	% in HFZ*	% Not in HFZ*	% in HFZ*	% Not in HFZ*
Aerobic capacity (1 mile run walk)	69,66	30,34	48,78	51,22	58,95	41,05	74,42	25,58	52,38	47,62
VO_{2max}	83,14	16,86	69,51	30,49	80,2	19,8	88,37	11,63	76,19	23,81
Body composition (BMI)	88,77	11,23	78,05	21,95	78,95	21,05	69,7	30,3	59,9	40,1
Abdominal strength (curl up)	97,75	2,25	93,90	6,10	97,89	2,11	100	0	100	0
Trunk extension strength (trunk lift)	95,51	4,49	81,71	18,29	92,63	7,37	86,05	13,95	85,71	14,29
Upper body strength (push up)	85,39	14,61	67,07	32,93	55,29	44,71	83,72	16,28	66,67	33,33
Flexibility (back saver sit and reach)	62,92	37,08	70,73	29,27	77,89	22,11	90,70	9,30	90,48	9,52

* HFZ = Healthy Fitness Zone

Also results revealed that there were significant differences among differed ages in the one mile run-walk test ($F_{4,330}$=7,83 p<0,01)**,** body mass index ($F_{4,330}$=4,69 p<0,01), curl up test ($F_{4,330}$=117,88 p<0,01), VO_{2max} ($F_{4,330}$=2,65 p<0,05), and trunk lift test ($F_{4,330}$=7,54 p<0,01). Also there were significant differences among males and females in the 1 mile run-walk test ($F_{1,330}$=117,82 p<0,05), curl up test ($F_{1,330}$=7,38 p<0,01), VO_{2max} ($F_{1,330}$=109,75 p<0,01) and in the back saver sit and reach ($F_{1,330}$=13,64 p<0,01). Finally, there were no significant differences among different ages or sex for the push-up test.

Discussion

The study was designed to gather baseline data on health-related physical fitness parameters of young aged 12-16 years, using a recognized test battery. One method for interpreting physical fitness level of young is to apply criterion-referenced standards, which are linked to health outcomes. Fitnessgram use this kind of approach in the test that recommends. For cardiorespiratory fitness almost 79% of students met these standards, indicated that almost one fifth of our sample failed to meet the level of cardiorespiratory fitness deemed appropriate by experts. The percentage for Greek children was lower comparing to the American children (California Department of Education, 2006), where 41-52% were out of the “healthy fitness zone”. This is important and must be considered by the physical educators in schools, when it is well documented that low levels of cardiorespiratory fitness is a strong risk factor for cardiovascular disease (Guo et al. 2002) and low cardiorespiratory fitness in adolescence predicts adult obesity and poor lipid profile (Hasselstrom et al. 2002).

Our findings in this study, that boys had a mean VO_{2max} approximately 16% higher than the girls in the overall sample were not surprising, because the same comparable differences were reported in previous survey and absolute levels of cardiorespiratory fitness differ between females and males (Gulati et al. 2005). In males fitness increased with age, but decreased with age in females and these differences were significant in both sexes. This could be explained by physical development factors such as sex-related changes in lean weight and fat weight during puberty (Krahenbuhl et al. 1985), or by the difference in physical activity levels during adolescence that decline rapidly in females (Pate et al. 1994). Another indication of the lower fitness generally in girls was that only 16% of the tested girls, compared to 24% of boys, belonged to the “best zone” of VO_{2max} test, according to the criterion reference standards of the Fitnessgram test battery, possibly reflecting an increasing motivation for maximal exercise in boys.

Regarding the body composition, a high percentage (24, 9%) of overweight and obese children were found in our study and this confirmed by other studies too, like Ogden et al. (2006), who reported that in the United States 17.1% of children and adolescents were overweight, or from another study (Hedley et al. 2004) who found that the prevalence of overweight among females was 16.6% and among males was 18.2%. Similar trends in childhood obesity have been noted in Australia (Dollman et al. 1999), while in a study from Greece (Tokmakidis et al. 2006) the percentage of overweight and obese children was 40.6%. It is difficult to explain the relationship between nutrient intake and obesity because of the diverse eating patterns (Randall et al. 1989), but the high BMI levels observed in the study may be explained, in part, by today's children's sedentary lifestyle, the increased inactivity as well as their dietary patterns. The “Westernized” diet, that includes higher intake of total and saturated fat and a lower amount of complex carbohydrates, when it is compared to the traditional “Mediterranean” diet, is probably responsible for the excess body weight of students.

The process by which excess body weight develops is complex and involves both lifestyle and genetic determinant factors. As lifestyle contributors to increased body weight we can mention the excess energy intake that includes the intake of excess food, sweets, large portion sizes, and the frequency of meals and snacks. Also, up to 70% of interindividual differences in BMI have been estimated that could be explained by genetic influences (Maes et al. 1997). Furthermore, heredity is estimated to account for 30-40% of such interrelated factors as adipose tissue distribution, physical activity, energy expenditure, eating behaviors, food preferences, lipoprotein lipase activity (Hebebrand et al. 2001, Ravussin et al. 2000). Because childhood obesity is predictive for the adult obesity (Lee et al. 1999), it is important to develop and evaluate interventions designed to start early in childhood. Systematic reviews confirm the persistence of obesity from childhood into adulthood (Whitlock et al. 2005).

Guo et al. (2002) analyzed lifelong data from the Fels Longitudinal Study and estimated the probabilities of having a BMI of 30 kg/m^2 at 35 years of age. For girls with BMI of 95th percentile during childhood, the probabilities of being obese as adults were 60% from 12 to 20 years of age. For boys with BMI of 95th percentile during childhood, the probabilities of being obese as adults were 40-60% from 11 to 16 years of age.

Balanced, healthy function of the musculoskeletal system requires that muscles be able to exert force (measured as strength), resist fatigue (measured as muscular endurance), and move freely through a full range of motion (measured as flexibility). Positive relationships have been demonstrated between musculoskeletal fitness and health status (LaMonte et al. 2005). Concerning the hamstring flexibility, significant differences were found between boys and girls of different ages. Girls achieved better results than the boys. These findings are in consistence with Bale et al. (1992) that girls were superior in flexibility. A percentage of about 78% for both boys and girls was in the Healthy Fitness Zone as this indicated by the Fitnessgram test, achieving higher levels of flexibility than those reported by California Department of Education, (2006).

Push-ups measure the muscular endurance capacity of the upper body. The results in the present study showed that sex did not constitute a defining factor for the performance to the above test, because boys did not execute more repetitions than girls. With girls executing the push-up test using their knees to support the body, the majority of children could successfully perform the 90° push-up test and only just 5% of the participants could not execute not even one repetition and this agree with the results of another study (Massicotte, 1990).

We did not found differences between males and females in the 90^o push-up test probably because of the different way that the test executed between males and females. It is known that muscular strength, from the upper body, the upper limbs and the shoulder, is more developed in boys than girls of the same height and mean power increases significantly in boys than girls between 12 to 13 years of age (Armstrong et al. 1998). Although muscular strength usually increases with an average of 5-10% per year, (McParland et al. 1995) independently of the height, the non significant differences in the muscular strength, between ages, seems to be more an issue of other factors that influence the results. These could be body growth, level of physical activity, nutritional conditions or biological age (Enright et al. 1994).

Results also showed that boys performed more curl-ups than girls of the same age because strength of the trunk muscles is related to muscular mass, and there are differences between the muscular mass at these ages between boys and girls. Also with the increase of age, there was also an increment in the number of the executed curl ups, probably because muscular strength increases with an average 5-10 % per year (Asmussen, 1973).

To our knowledge, there were only a few studies in Greece to evaluate the level of fitness using test batteries for all components of fitness in young adolescents. Therefore more studies are necessary to evaluate the national level of fitness at these ages in Greece. Those findings should help the physical education teachers to provide effective lessons plans for the physical education class in schools, and these interventions are necessary and important to start in early childhood. An effective public health approach must promote the physical education class in schools because both males and females students could benefit from a greater emphasis on all areas of physical fitness, especially aerobic capacity, body composition, upper body strength, and flexibility.

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