# Physical fitness and body mass index in Greek high school students 

Argiropoulou, E.C. ${ }^{*}$, Michalopoulou, M., Douda, H., Agelousis, N.<br>Department of Physical Education \& Sport Science, Democritus University of Thrace, Komotini, 69100, Greece


#### Abstract

The aim of this study was to determine the relationship between performance in physical fitness tests and Body Mass Index in high school students in Greece. Participants in this study were 472 high school students, 219 boys aged $13.14 \pm 0.84$ years and 253 girls aged $13.06 \pm 0.90$ years. Performance in physical fitness components was assessed with Fitnessgram Test Battery. The body mass index (BMI) cut-off points adopted by the International Obesity Task Force were utilized for the assessment of overweight and obesity. According to the results of this study statistically significant effects were reported for both boys and girls between BMI categories for push-ups (only boys), curl ups (only girls) and aerobic capacity ( $\mathrm{VO}_{2} \mathrm{max}$ ), where higher percentages of overweight and obese participants were in the under healthy fitness zone (UHFZ). Age affected several of the physical fitness parameters and statistically significant BMI effects were reported with overweight and obese participants achieving lower scores in the assessment tests. In conclusion BMI status in Greek high school students both boys and girls, seems to be negatively related to lower fitness levels.


Keywords: adolescent; obesity; aerobic capacity; muscular strength and endurance; flexibility.

## 1 Introduction

Obesity is a chronic disease requiring lifelong attention to healthy eating and an active lifestyle (Barlow \& Dietz, 1998). Adiposity status is largely determined by genetics and an environment that encourages an adverse balance between energy intake and energy expenditure (Dietz \& Gortmaker, 2001).

Childhood obesity has important consequences for health and wellbeing both during childhood and also in later adult life. The rising prevalence of childhood obesity poses a major public health challenge in both developed and developing countries by increasing the burden of chronic noncommunicable diseases (Lakshman, Elks \& Ong, 2012). Obese children develop serious medical and psychosocial complications, and are at greatly increased risk of adult morbidity and mortality (Ebbeling, Pawlak \& Ludwig, 2002). The economic burden of obesity in youth and adults is also considerable (Dee et al., 2014; Vellinga, O'Donovan, \& La Harpe, 2008; Wang \& Dietz, 2002).

Existing research evidence in Greece suggests an alarmingly high prevalence of overweight and obesity among Greek children and adolescents. During the decade 20012010, $1 / 10$ children aged 1-12 years was obese and $3 / 10$ were overweight (Kotanidou et al., 2013) and the overall prevalence of overweight and obesity in adolescents aged 1319 years was $29.4 \%$ in boys and $16.7 \%$ in girls (Tzotzas et al., 2008).

Body mass index (BMI) has been selected to assess obesity in children although is not a perfect measure (Bellizzi \& Dietz, 1999). Despite a number of limitations, BMI is a valid and feasible indirect measure of body fatness and it is very useful in clinical practice and in epidemiologic studies (Wang, 2004). The International Obesity Task Force (IOTF) has been provided cut off points for BMI in childhood that are based on international data and linked to the widely-accepted adult cut off points of a body mass index of 25 and 30 $\mathrm{kg} / \mathrm{m}^{2}$. These cut off points are recommended for use in international comparisons of prevalence of overweight and obesity (Cole et al., 2000).

The findings of many reviews indicate that there is a strong, consistent evidence of favorable relationships between physical activity (PA), physical fitness (PF) and adiposity in school-aged children and youth (Janssen \& LeBlanc, 2010; Ortega et al., 2008; Poitras et al., 2016).

Physical fitness is a state of being that reflects a person's ability to perform specific exercises or functions, and is related to present and future health outcomes (Committee on Fitness Measures and Health Outcomes in Youth, 2012). Fitnessgram battery test categorizes the dimensions of health-related fitness into three main categories: 1) aerobic capacity or cardiorespiratory fitness (CRF), 2) musculoskeletal fitness including muscle strength, muscular endurance, and flexibility, and 3) body composition (Eisenmann et al., 2013).

While several studies reported the relationship between CRF and obesity (BMI) few studies assess other fitness outcomes associated with obesity. Additionally, relatively few data are available examining associations of obesity to fitness in Greek children with the use of Fitnessgram test that introduced the Healthy Fitness Zone (HFZ) categorization. Therefore, the aim of this study was to determine the relationship between performance in health related physical fitness parameters and Body Mass Index in 12-14-year-old high school students in Greece.

## 2 Method

### 2.1 Participants

Participation was on a voluntary basis from seven high schools in Attica region with cluster sampling concerning the selection of schools and a total number of 472 healthy children ( 219 boys and 253 girls) aged $13.09 \pm 0.87$ years obtained written parental consent, after full explanation of the testing procedures. The research ethics committee of the Democritus University of Thrace approved the study. All measurements were conducted during morning school visits (i.e. 08:00-12:00 a.m., during Physical Education classes) by experienced researchers using identical protocols. The data collected included anthropometric measurements, as well as physical fitness parameters.

### 2.2 Anthropometry

Height was measured in the Frankfort horizontal plane using a Seca 206 stadiometer to the nearest 0.1 cm and body mass was measured to the nearest 0.1 kg with an electronic weight scale (Beurer PS 07). Height and weight of students were measured barefoot and in light clothing.

The BMI was calculated from the ratio weight/height ${ }^{2}\left(\mathrm{~kg} / \mathrm{m}^{2}\right)$ and organized using age and sex adjusted cut-off points described by Cole and colleagues (2000). Then participants were categorized as normal weight, overweight or obese group.
Skinfold thicknesses ( mm ) were measured at the right side of the body to the nearest 0.1 mm with a skinfold caliper (Harpenden, Skinfold Caliper, UK), and the mean of three measurements was taken. The measurements were taken at: (i) triceps, on the back of

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the arm over the triceps muscle, midway between the elbow and the acromion, and (ii) calf, on the inside of the leg at the level of maximal girth.

In this study, the percentage of body fat (\%BF) was predicted from a two-compartment model, using the equations proposed by Slaughter et al. (1988), as these equations are used in Fitnessgram Test Battery and have been showed the closest agreement with DXA in adolescents of both sexes (Rodrıguez et al., 2005).

### 2.3 Physical Fitness

Health-related components of PF were evaluated using the Fitnessgram Test Battery 9.0. Fitnessgram uses criterion-referenced standards to evaluate fitness performance. Many of these standards have been established to represent a level of fitness that is associated with some degree of protection against chronic disease. In Fitnessgram performance on musculoskeletal components (strength, endurance, and flexibility) is classified in two general areas: the "Healthy Fitness Zone" (HFZ) and the "Needs Improvement Zone" (NIZ). Performance on the body composition and aerobic capacity components is classified in three general areas: the "Healthy Fitness Zone" (HFZ), the "Needs Improvement Zone", and a "Needs Improvement-Health Risk Zone" (Meredith et al., 2013). In the present study all subjects underwent five health-related fitness tests included 20 meters multistage shuttle run test Progressive Aerobic Cardiovascular Endurance Run (PACER) (aerobic capacity), curl-up (abdominal strength and endurance), trunk lift (trunk extensor strength and flexibility), $90^{\circ}$ push-up (upper body strength and endurance) and back-saver sit and reach (flexibility). Aerobic capacity $\left(\mathrm{VO}_{2} \mathrm{max}\right)$ was predicted using a new equation that the FITNESSGRAM Scientific Advisory Board formally adopted because it avoids a potential systematic underestimation of $\mathrm{VO}_{2}$ peak in overweight or obese youth (Burns et al., 2015).

The test results were split in two fitness categories such as under healthy fitness zone (UHFZ), equivalent to "Needs Improvement" and "Needs Improvement-Health Risk", and healthy fitness zone or above (HFZ). To be the students in the HFZ for the back-saver sit and reach test should meet the standard on both the right and the left sides. The Fitnessgram Test Battery was chosen because of its simplicity of administration to large samples, its reliability and validity (Aires et al., 2008). Students were familiarized with the procedure for each test before recording data. The participants received verbal encouragements from the investigators in order to achieve maximum performance.

### 2.4 Statistical Analysis

Descriptive statistics were used to describe participants' anthropometrical characteristics as well as performance in physical fitness tests according to sex and BMI. Mean values and standard deviations were used for continuous variables while absolute and relative frequencies were used for qualitative variables for the following physical fitness parameters (aerobic capacity, abdominal strength and endurance, trunk extensor strength and flexibility, upper body strength and endurance, flexibility). Chi square ( $x^{2}$ ) was used to test for differences concerning physical fitness parameters (PACER, curl -ups, trunk lift, $90^{\circ}$ push-ups, back-saver sit and reach) in both boys and girls according to BMI categories and the two fitness categories (HFZ and UHFZ). Additionally, multivariate analysis (MANCOVA) by gender and adjusted for age was used, in order to analyze physical fitness parameters as dependent variables and BMI as independent parameter. SPSS version 15.0 (Statistical Package for Social Sciences, SPSS Inc, Illinois, USA) software was used for data statistical analysis. The level of significance was set at .05 .

## 3 Results

Participants' anthropometric characteristics are presented in Table 1 as mean values (M), and standard deviations (SD). Boys presented higher prevalence of overweight and obesity ( $23.7 \%$ and $4.6 \%$ ) than girls ( $15.4 \%$ and $4.7 \%$ ) without differences between genders ( $x^{2}=5.25, p=.072$ ). Both boys and girls showed significant differences in anthropometric measures among the three BMI categories and particularly for body weight, percentage of body fat and BMI values.

Table 1. Description of the subjects by gender and BMI category (mean $\pm$ SD)

| Boys N=219 (46.4\%) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Normal $\mathrm{n}=157$ <br> (71.7\%) | $\begin{gathered} \hline \text { Overweight } \\ \mathrm{n}=52 \\ (23.7 \%) \\ \hline \end{gathered}$ | $\begin{gathered} \hline \text { Obese } \\ \mathrm{n}=10 \\ (4.6 \%) \\ \hline \end{gathered}$ | p |
| $\mathrm{M} \pm$ SD |  |  |  |  |
| Age (years) | $13.20 \pm .86$ | $12.96 \pm .73$ | $13.12 \pm .98$ | . 199 |
| Weight (kg) | $48.39 \pm 9.38{ }^{*}$,** | $60.75 \pm 8.42$ ** | $73.97 \pm 12.12$ | . 000 |
| Height (m) | $1.60 \pm .09$ | $1.60 \pm .09$ | $1.60 \pm .09$ | . 928 |
| $\begin{gathered} \mathrm{BMI} \\ \left(\mathrm{~kg} / \mathrm{m}^{2}\right) \end{gathered}$ | $18.73 \pm 1.96 *$,** | $23.46 \pm 1.36$ ** | $28.4 \pm 1.83$ | . 000 |
| \%Body Fat | $17.79 \pm 6.35 * * *$ | 30.64 $\pm 7.91 * *$ | $44.76 \pm 9.03$ | . 000 |
| Girls N=253 (53.6\%) |  |  |  |  |
|  | Normal $\mathrm{n}=202$ <br> (79.8\%) | $\begin{gathered} \text { Overweight } \\ \mathrm{n}=39 \\ (15.4 \%) \end{gathered}$ | $\begin{gathered} \hline \text { Obese } \\ \mathrm{n}=12 \\ (4.7 \%) \end{gathered}$ | p |
| $\mathrm{M} \pm$ SD |  |  |  |  |
| $\begin{gathered} \text { Age } \\ \text { (years) } \end{gathered}$ | $13.08 \pm .89$ | $12.93 \pm .93$ | $13.14 \pm 1$. | . 617 |
| Weight (kg) | $47.55 \pm 6.76{ }^{*}$,** | 59.91 $\pm 6.73$ ** | $77.30 \pm 8.05$ | . 000 |
| Height <br> (m) | 1.58土. 06 | $1.57 \pm .05$ | $1.58 \pm .07$ | . 906 |
| $\begin{gathered} \mathrm{BMI} \\ \left(\mathrm{~kg} / \mathrm{m}^{2}\right) \end{gathered}$ | 18.88さ1.91*** | $23.97 \pm 1.67 * *$ | $30.68 \pm 2.7$ | . 000 |
| \%Body Fat | $22.79 \pm 4.84$ *,** | $33.94 \pm 6.68 * *$ | $44.52 \pm 9.63$ | . 000 |

*different from overweight, ** different from obese
Results from chi square ( $\mathrm{x}^{2}$ ) tests are presented in Table 2. A significant effect was reported for boys, between BMI categories for trunk lift, push-ups and for PACER where higher percentages of overweight and obese participants were in the UHFZ. As for girls, significant effects were reported for trunk lift, curl up and for PACER according to which higher percentages of overweight and obese participants were in the UHFZ.

Table 2. Physical fitness categories according to BMI.

|  |  | Boys |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Fitness | Fitness <br> Tests | Normal <br> $\%$ | Overweight $\%$ | Obese <br> $\%$ | $X^{2}$ value |


| Trunk lift | HFZ | 53.8 | 75 | 80 | 9.00* |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | UHFZ | 46.2 | 25 | 20 |  |
| Curl Up | HFZ | 73.5 | 73.1 | 66.7 | . 20 |
|  | UHFZ | 26.5 | 26.9 | 33.3 |  |
| Back-saver sit and reach | HFZ | 34 | 34.6 | 40 | . 15 |
|  | UHFZ | 66 | 65.4 | 60 |  |
| $90^{\circ}$ push-up | HFZ | 65.2 | 40.4 | 0 | 23.17** |
|  | UHFZ | 34.8 | 59.6 | 100 |  |
| PACER ( $\mathrm{VO}_{2} \max$ ) | HFZ | 86.8 | 69.2 | 22.2 | 26.56** |
|  | UHFZ | 13.2 | 30.8 | 77.8 |  |
|  |  | Girls |  |  |  |
| Fitness Tests | Fitness Categories | Normal \% | Overweight \% | Obese \% | $\mathrm{X}^{2}$ value |
| Trunk lift | HFZ | 63.4 | 82.1 | 91.7 | 8.54* |
|  | UHFZ | 36.6 | 17.9 | 8.3 |  |
| Curl Up | HFZ | 69.2 | 38.5 | 25 | 20.56** |
|  | UHFZ | 30.8 | 61.5 | 75 |  |
| Back-saver sit and reach | HFZ | 47.8 | 38.5 | 66.7 | 3.04 |
|  | UHFZ | 52.2 | 61.5 | 33.3 |  |
| $90^{\circ}$ push-up | HFZ | 33.7 | 23.1 | 16.7 | 2.94 |
|  | UHFZ | 66.3 | 76.9 | 83.3 |  |
| PACER ( $\mathrm{VO}_{2} \max$ ) | HFZ | 56.8 | 21.6 | 0 | 26.49** |
|  | UHFZ | 43.2 | 78.4 | 100 |  |

*p<.05, **p<. 001
Additionally, multivariate analysis results for boys revealed a significant age effect for the physical fitness parameters of flexibility of right side and cardiovascular fitness while for girls, age effects were significant for curl ups, right side flexibility, push-ups and cardiovascular fitness. Furthermore, significant BMI effects were reported for boys for curls ups (Figure 1), $90^{\circ}$ push-ups (Figure 2) and PACER (Figure 3) while for girls the respective effects were reported for curl ups and PACER. No statically significant BMI effects were reported for boys and girls for trunk lift (Figure 4) and back saver sit and reach test (Figure 5).


Figure 1. Differences in abdominal strength and endurance among BMI categories by gender, *p<0.05 ( $a=$ normal, $b=o v e r w e i g h t, ~ c=o b e s e) . ~$


Figure 2. Differences in upper body strength and endurance among BMI categories by gender, $\mathrm{p}<0.05,{ }^{* * *} \mathrm{p}<.001$ ( $\mathrm{a}=$ normal, $\mathrm{b}=0$ verweight, $\mathrm{c}=\mathrm{obese}$ ).


Figure 3. Differences in aerobic capacity among BMI categories by gender, *p<0.05, ** $\mathrm{p}<.01$, *** $\mathrm{p}<.001$ ( $\mathrm{a}=$ normal, $\mathrm{b}=$ overweight, $\mathrm{c}=$ obese).


Figure 4. Differences in trunk extensor strength and flexibility among BMI categories by gender.


Figure 5. Differences in flexibility on the right and left sides of the body among BMI categories by gender.

## 4 Discussion

The aim of this study was to determine the relationship between performance in health related physical fitness parameters and Body Mass Index in high school students in Greece.

Physical fitness is widely recognized as a powerful marker of current and future cardiovascular, skeletal and mental health (Catley \& Tomkinson, 2013) and there is strong evidence indicating that cardiorespiratory fitness levels are associated with total and abdominal adiposity (Ortega et al., 2008).

The percentage of overweight and obesity in this study, respectively $23.7 \%$ and $4.6 \%$ for boys and $15.4 \%$ and $4.7 \%$ for girls was below the values described for children and
 Patsopoulou et al., 2015; Tzotzas et al., 2011). Regarding gender differences and in accordance with other Greek studies, the prevalence of overweight and obesity was
slightly higher among boys without achieving statistical significance, confirming that the problem of obesity characterizes both genders (AvTwvióסŋns et al., 2014; Antoniades, Douda, Papazoglou, \& Tokmakidis, 2016; $\Delta$ oúסа et al., 2009; Tokmakidis, Kasambalis, \& Christodoulos, 2006; Хрıотóסou入os et al., 2009).

The findings of this study are in agreement with other studies showing that overweight and obese youth are generally less fit than normal weight counterparts except flexibility (Aires et al., 2008; Artero et al., 2010; Casajus et al., 2007; Mak et al., 2010; Tokmakidis et al., 2006). More specifically overweight and obese adolescents achieve lower performances in all tests requiring propulsion or lifting of the body mass. These poorer performances are probably due to the fact that their excess body fat is an extra load to be moved during weight-bearing tasks (Artero et al., 2010; Casajus et al., 2007; Mak et al., 2010). Another explanation could be that obese children and adolescents avoid weightbearing activities because of the greater energy cost compared with normal-weight children. In this case, the poorer performance could also be a consequence of a lack of experience in weight-bearing tasks. Subsequently, their poor performance in the physical fitness tests is potentially a consequence of lack of motor learning in these tests (Gonzalez-Suarez et al., 2011). On the other hand the results of the present study confirm that in tests requiring flexibility, coordination, or speed of limb movement excess fatness is not likely to hinder performance (Deforche et al., 2003).

Regarding to aerobic capacity in the present study the total sample (100\%) of obese girls and $77.8 \%$ of obese boys as well as $30.8 \%$ of overweight boys and $78.4 \%$ of overweight girls were considered unfit. In a similar study (Aires et al., 2008) from Portugal the total sample ( $100 \%$ ) of obese boys and girls as well as more than $50 \%$ of overweight boys and girls ( $52.4 \%$ and $64.3 \%$, respectively) were considered unfit. In the study of Laparidis and colleagues (2008) from Greece almost one fifth of the sample ( 330 boys and girls aged 12-16 years) failed to meet the level of cardiorespiratory fitness from PACER test. In the study of Guedes and colleagues (2012) 54.9\% of Brazilian girls and $44.5 \%$ of Brazilian boys aged 10-14 years didn't attain the health criteria for cardiorespiratory fitness from Fitnessgram. Respective data from United States of America from the National Health and Nutrition Examination Survey (NHANES) 19992004, and the NHANES National Youth Fitness Survey 2012, revealed that one-half of boys and about one-third of girls aged 12-15 years had adequate levels of cardiorespiratory fitness. In the same study a higher percentage of boys (50.2\%) had adequate levels of cardiorespiratory fitness compared with girls of the same age (33.8\%). Finally the percentage of youth who had adequate levels of cardiorespiratory fitness decreased as weight status increased, a higher percentage of normal weight youth (54.1\%) had adequate levels of cardiorespiratory fitness compared with overweight (29.9\%) or obese (20.0\%) youth (Gahche et al., 2014).

It should be noted that possible observed differences in predicted values of $\mathrm{Vo}_{2} \max$ and consequent HFZ frequencies are due to different equations use. The Fitnessgram Scientific Advisory Board implemented recent changes to scoring procedures for the PACER. A new model to estimate $\mathrm{VO}_{2}$ max from PACER laps and age was developed. This equation was developed on a large sample of children aged 10 to 18 years. Other variables, including BMI , were considered for inclusion in the equation, but it was determined that an equation without BMI solves several problems for many users of the Fitnessgram and it was only slightly less accurate than a comparable equation with a body composition term. Use of this new PACER equation means that all students of the same age and sex must complete the same number of laps to reach the HFZ (Cuerton \& Mahar, 2014). The elimination of BMI as a predictor variable in models may have marginally decreased predictive accuracy but did not comprise the criterion-referenced validity evidence. The new equation compared favorably to the older models and show promise

JOURNAL OF PHYSICAL ACTIVITY
for utility in physical education settings due to the elimination of the BMI predictor and strong criterion-referenced classification agreement with measured $\mathrm{VO}_{2}$ Peak into Healthy Fitness Zones (Burns et al., 2015).

In parallel with the childhood obesity epidemic, type II diabetes and clustering of cardiovascular risk factors are increasingly reported among children and adolescents. Overweight children may reduce cardiovascular risk through improved cardiorespiratory fitness even without weight loss and moderate-to-vigorous physical activity improves maximal respiratory fitness and can be used as a strategy to improve fitness (Kwon, Burns \& Janz, 2010). Enhanced fitness performance mostly reflects the level of habitual physical activity (Tokmakidis et al., 2006). It seems that physical education class in Greek high school is not health-oriented and focuses mainly on teaching sport skills and only $12.3 \%$ of the lesson's time is devoted to promoting PF (Kó $\sigma \sigma \cup \beta \alpha \&$ Хaт nхарıбтós, 2007). The $^{2}$ current national Greek PE program is associated with low fitness levels in general, and, worryingly, it is insufficient to bring about beneficial adaptations in cardiovascular fitness regarding future cardiovascular health (Koutedakis \& Bouziotas, 2003). On the other hand children who participated in a community-based sport skills learning program reported significantly more PA and spent more time in moderate to vigorous and vigorous PA. During a typical $60-\mathrm{min}$ training session, children perform several drills for learning both the skills and the tactical elements involved in each sport and at the same time improve their physical fitness in order to be able to participate in a game or competition. Additionally, children who participated in a community-based sport skills learning program had higher aerobic capacity and abdominal strength than those who participated only in physical education classes (Dimitriou et al., 2011).

## 5 Conclusions

Physical fitness should be considered as a useful health marker already in childhood and adolescence, reinforcing the need to include physical fitness testing in health monitoring systems. Physical fitness enhancement, through increases in the time spent in vigorous physical activity and high intensity training, should be a major goal in current and future public health promotion policies. School may play an important role by helping to identify children with low physical fitness, and by promoting positive health behaviors such as encouraging children to be active, with special emphasis on the intensity of the activity (Ortega et al., 2008). The main strength of this study was the use of several tests for fitness assessment and the main limitation was that the sample was restricted to Attica region, Greece.
The data of this study call for the development of effective preventive strategies either for all unfit children or targeted towards those in high risk such as overweight/obese girls (Aires et al., 2008).

In conclusion, this study adds data to the current database concerning to the relationship between performance in physical fitness tests and BMI in high school students in Greece. The results suggest that obese and overweight children have low PF level compared to normal weight peers.

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