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PHYSICAL FITNESS LEVELS OF BULGARIAN PRIMARY SCHOOL CHILDREN IN RELATIONSHIP TO OVERWEIGHT AND OBESITY

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ABSTRACT
The health-related physical fitness of children, alongside overweight and obesity rates, have been shown to be of great interest amongst physical education teachers, sports coaches, scientists, and health practitioners. Physical fitness is a major factor, which can predict the health status in the later phases of children lives. The aim of this study was to assess the health-related physical fitness levels in primary school children, in addition to providing estimates for overweight and obesity for children at this age. This study consisted of 118 primary school children (64 girls and 54 boys from Sofia, Bulgaria) between the ages of 7 and 11. The participants completed the Alpha-Fit health-related physical fitness test battery, which included anthropometric measurements and different tests (handgrip strength, standing long jump, 4x10m shuttle run test, and 20m multistage fitness test). The mean percentile scores of height, weight and BMI in all participants were within the WHO norms. However, the individual BMI assessment showed that 20.3% of all primary school children were 'overweight' (BMI > 85th percentile), 8.5% were 'obese' (BMI > 97th percentile), and 13.5% were assessed as 'thin' (BMI < 15th percentile). The results of this study showed that lower levels of physical fitness are associated with overweight and obesity in primary school children.

Key words: *physical fitness, children, Alpha-Fit, overweight, obesity*

INTRODUCTION

The health-related physical fitness in children has been shown to be of great importance for children's development, and has been widely discussed in the field of physical education and sport. Physical fitness is considered as a key factor in childhood (Ruiz et al., 2006, Ortega et al., 2008), and can be used to monitor and predict the health status of children (Ruiz et al., 2009). Measuring anthropometric parameters, as well as testing physical fitness components, is crucial in order to make a comprehensive assessment of the health-related physical fitness of children. A comprehensive review in many longitudinal studies concluded that a higher level of cardiorespiratory fitness, muscular strength and body composition is associated with a healthier cardiovascular profile and with a lower risk of developing cardiovascular diseases, and a healthier body composition in childhood is also associated with a lower risk of death in adulthood (Ruiz et al., 2009). Those health-related components are the core of the Alpha-fit test battery, which was designed to provide instruments for assessing physical fitness in a comparable way within the European Union (ALPHA, 2009). Based on a substantial number of studies, the Alpha-fit battery provides a full set of valid, reliable, feasible and safe field-based fitness tests to be applied for health monitoring purposes in children (Santos and Mota, 2011, ALPHA, 2009, Espana-Romero et al., 2010, Ruiz et al., 2010).

Interest in assessing and monitoring children's physical fitness has grown substantially over the last few decades due to a variety of health issues, such as overweight and obesity, as well as uncommon diseases for this age, for instance, diabetes and high blood pressure.

Aim And Objectives Of The Study

The aim of this cross-sectional study was to assess the health-related physical fitness levels in boys and girls between the ages of 7 and 11, in addition to providing estimates for overweight and obesity in a sample of primary school children from Sofia, Bulgaria. The realisation of this aim implies the following objectives: measurement and assessment of anthropometric parameters, testing and evaluating musculoskeletal fitness, motor fitness and cardiorespiratory fitness.

METHODS

This study consisted of 118 primary school children between the ages of 7 and 11, who were divided by

their gender into two groups: 64 girls with a mean age of 9.1 ± 1.0 years, and 54 boys with a mean age of 9.1 ± 1.0, from Sofia, Bulgaria. In addition, the sample was also divided based on their BMI assessment (children with BMI percentile score (PRs) within the norms vs overweight or obese children), in order to investigate whether levels of physical fitness are associated with overweight and obesity in the primary school children. The study was carried out at the 'Hadji Dimitar' Primary School N42 and 'Nikolay Hrelkov' Primary School N53 during the spring of 2019. Informed consent for this research was obtained from the parents of each child prior to testing.

The participants of this study completed the Alpha-Fit health-related physical fitness test battery (ALPHA, 2009), which includes different anthropometric measurements (height, weight, waist circumference, triceps and subscapular skinfolds), as well as a variety of different fitness tests (handgrip strength, standing long jump, 4x10m shuttle run test, and 20m multistage fitness test). The body mass index (BMI) with the percentile scores for height, weight and BMI for each child were calculated and evaluated by using the WHO AnthroPlus software (WHO, 2011). The percentile scores (PRs) were assessed by using the following classification: BMI > 85th PRs - 'overweight'; BMI > 97th PRs - 'obese'; BMI < 15th PRs - 'thin'; and BMI < 3rd PRs - 'severely thin' (WHO, 2007a). In addition, waist-to-height ratio (WHtR) was calculated (waist circumference (cm) / height (cm)). Furthermore, upper arm muscle area (UAMA) was also calculated by using the following formula (UAMA = [Arm circumference – (π x triceps skinfold)]2 ÷ 4 x π), and its percentile scores were computed based on recent norms for children (Addo et al., 2017).

The body fat percentage (%Fat) was calculated as the sum of two skinfolds, using Slaughter's equations (Slaughter et al., 1988), and the body fat PRs were computed by using international norms for children (McCarthy et al., 2006).

Handgrip strength was measured by using the TKK digital hand dynamometer (TKK 5101 Grip-D, Japan) and the individual optimal grip span was calculated for each child prior to testing by using the equations for girls and boys between the ages of 6 and 12 (Espana-Romero et al., 2008). The standing long jump test was recorded to within an accuracy of 1 cm, and the 4x10m shuttle run test was performed by using a stopwatch to an accuracy of 0.1 sec. Percentile scores for the handgrip strength, standing long jump and 4x10m shuttle run tests were calculated by using the full set of recently proposed values for the tests from the Alpha-Fit battery in European children (Kolimechkov et al., 2019). The software, specialised for children, this being BeepShuttle Junior (Kolimechkov et al., 2018, BeepShuttle Junior, 2017) was applied to administer the 20m multistage fitness test with the original 1-minute protocol, as described by Leger et al. (Leger et al., 1984), and to calculate the estimated maximal oxygen uptake (VO_2max). In order to assess the VO_2max of the participants, BeepShuttle Junior also computed the percentile score for each individual based on age- and gender-specific international norms (Miguel-Etayo et al., 2014, Tomkinson et al., 2016).

The statistical analyses were conducted with SPSS Statistics 19, IBM, USA software, using descriptive statistics and the Kolmogorov-Smirnov test of normality. The parameters which showed a normal distribution were compared by using the independent t-test, and those with an abnormal distribution by applying the non-parametric Mann-Whitney U test. Statistically significant differences between the mean values were evaluated at $p < 0.05$, and all data in the manuscript are presented as mean ± SD. Percentile scores (PRs) were compared to the 50th percentile of the norms for primary school children by using one sample t-test in order to support the results analyses.

RESULTS

The anthropometric parameters, with their corresponding percentile scores (PRs) of the primary school children, are presented in Table 1. There was no significant difference between the anthropometric parameters of the children of both genders. The mean PRs of height, weight, and BMI in the primary school children were within the normal WHO international norms (> 15th PRs and < 85th PRs). Similarly, the mean PRs of %Fat were also within the healthy norms. The mean BMI PRs for girls did not differ significantly from the 50th percentile (56.4 PRs, $p > 0.05$), and the BMI PRs for boys was slightly higher than the 50th percentile of the WHO norms for BMI (59.8 PRs, $p < 0.05$). The mean upper arm muscle area (UAMA) PRs for the girls and boys did not differ significantly from the 50th percentile of the children's norms (Table 1).

Table 1. *Anthropometric parameters, with their corresponding percentile scores, of the primary school children divided by their gender (mean ± SD).*

	Girls (n=64)	**Boys** (n=54)	**p**
Age (years)	**9.09** ± 1.02	**9.14** ± 1.01	p > 0.05*
Height (cm)	**136.77** ± 10.51	**137.98** ± 9.98	p > 0.05 x
Height – percentile score	**61.72** ± 27.97	**68.39** ± 25.36	p > 0.05 x
Weight (kg)	**32.60** ± 8.86	**32.75** ± 6.94	p > 0.05 x
Weight – percentile score	**59.06** ± 30.82++	**66.03** ± 31.22++	p > 0.05 x
BMI (kg/cm²)	**17.19** ± 2.78	**17.03** ± 2.14	p > 0.05 x
BMI – percentile score	**56.43** ± 31.38	**59.84** ± 30.24	p > 0.05*
Arm circumference (cm)	**20.23** ± 2.59	**20.27** ± 2.77	p > 0.05 x
Waist circumference (cm)	**58.54** ± 7.36	**60.27** ± 6.63	p > 0.05 x
Waist-to-height ratio	**0.43** ± 0.05	**0.44** ± 0.04	p > 0.05 x
% Fat	**18.39** ± 6.72	**16.72** ± 7.19	p > 0.05 x
% Fat - percentile score	**29.35** ± 36.66	**35.74** ± 35.48	p > 0.05 x
UAMA (cm²)	**21.42** ± 4.57	**22.63** ± 5.07	p > 0.05 x
UAMA – percentile score	**50.53** ± 25.48	**48.95** ± 34.12	p > 0.05 x

+ WHO does not provide weight-for-age reference data for children older than 10 years of age (WHO, 2007b).
++ n=52 for girls and n=42 for boys, because 24 of the children were older than 10 (see +).
** - compared by using the t-test for independent samples*
x - compared by using the Mann-Whitney U test for independent samples

The individual PRs of BMI in the girls showed that 9 of the 64 females were assessed as 'overweight', and 8 as 'obese'. Additionally, 15 of the 54 boys were assessed as 'overweight' and 2 as 'obese'. On the whole, the individual BMI assessment showed that 20.3 % (24 children) of all primary school children were 'overweight' (BMI > 85th PRs), 8.5 % (10 children) were 'obese' (BMI > 97th PRs), and 13.5 % (16 children) were assessed as 'thin' (BMI < 15th PRs).

The results from the Alpha-Fit health-related physical fitness tests, in addition to the corresponding PRs of the primary school children, divided according to gender, are presented in Table 2.

Table 2. Results from the Alpha-Fit health-related physical fitness tests, and the corresponding percentile scores of the primary school children, divided according to gender (mean ± SD).

	Girls (n=64)	**Boys** (n=54)	**p**
Musculoskeletal Fitness: Upper body strength			
Handgrip strength test† (kg)	**12.81** ± 3.46	**14.14** ± 3.15	p < 0.05 x
Handgrip strength test (percentile score)	**44.32** ± 26.89	**44.26** ± 28.51	p > 0.05*
Musculoskeletal Fitness: Lower body strength			
Standing long jump (cm)	**126.36** ± 20.30	**138.66** ± 21.81	p < 0.01*
Standing long jump (percentile score)	**61.24** ± 24.40	**61.72** ± 29.48	p > 0.05 x
Motor Fitness			
4x10 m shuttle run test (sec)	**14.24** ± 1.18	**13.48** ± 1.82	p < 0.001 x
4x10 m shuttle run test (percentile score)	**44.75** ± 22.58	**48.92** ± 29.43	p > 0.05 x
Cardiorespiratory Fitness			
VO_2max (ml/kg/min)	**47.24** ± 2.40+	**48.45** ± 3.22++	p < 0.05*
VO_2max (percentile score)	**62.57** ± 21.44+	**58.36** ± 22.68++	p > 0.05*

† - values expressed as average of right and left hands; *+ n=55, ++ n=46*
** - compared by using the t-test for independent samples*
x - compared by using the Mann-Whitney U test for indipendent samples

Overall, the boys had significantly better results in all fitness tests (Table 2), but the PRs were similar to those of the girls. The mean PRs of handgrip strength and 4x10 m shuttle run tests for both groups did not differ significantly from the 50th percentile of the international norms for European

children ($p > 0.05$). However, both groups showed significantly higher mean PRs in the standing long jump and VO_2max, in contrast with the 50th percentile of the international norms ($p < 0.05$).

The children classified as 'overweight' or 'obese' (BMI PRs > 85th) were compared to the children whose BMI PRs were within the norms (Table 3), in order to find out whether levels of physical fitness are associated with overweight and obesity. The children with normal weight had significantly lower PRs for weight, BMI, %Fat, and WHtR, in comparison with the children assessed as 'overweight' or 'obese', which showed that those anthropometric parameters provided an accurate assessment of body composition for the groups.

Table 3. Results from health-related physical fitness assessment of the children with normal BMI PRs and those assessed as 'overweight' or 'obese', BMI > 85th percentile (mean ± SD)

	Normal weight (n=84)	**Overweight and Obese** (n=34)	**p**
Age (years)	**9.14** ± 0.96	**9.04** ± 1.14	**p** > 0.05 x
Height (percentile score)	**61.41** ± 28.11	**73.09** ± 21.88	**p** > 0.05 x
Weight (percentile score)	**51.08** ± 28.89++	**92.79** ± 5.95++	**p < 0.001** x
BMI (percentile score)	**43.54** ± 24.39	**93.69** ± 4.20	**p < 0.001** x
% Fat (percentile score)	**14.07** ± 21.01	**77.25** ± 24.22	**p < 0.001** x
Waist-to-height ratio	**0.41** ± 0.03	**0.48** ± 0.04	**p < 0.001** x
Handgrip strength test (percentile score)	**41.66** ± 27.65	**50.80** ± 26.50	**p > 0.05** *
Standing long jump (percentile score)	**65.26** ± 25.90	**52.18** ± 26.73	**p < 0.05** x
4x10 m shuttle run test (percentile score)	**50.46** ± 24.37	**37.30** ± 27.41	**p < 0.05** x
VO_2max (percentile score)	**66.28** ± 20.52	**44.42** ± 17.93	**p < 0.001** *

++ *n=69 for 'normal weight' and n=25 for 'overweight and obese', because 24 of the children were older than age of 10 (WHO does not provide weight-for-age reference data for children older than 10 (WHO, 2007b)).*

* *- compared by using the t-test for independent samples*

x - compared by using the Mann-Whitney U test for independent samples

The PRs for the standing long jump test, 4x10 m shuttle run test, and VO_2max were significantly higher, and, therefore, favourable for children with normal weight, and there was no significant difference between the handgrip strength PRs of both groups, as shown in Table 3.

DISCUSSION

In this study, 24 children were assessed as 'overweight' and 10 as 'obese' according to their BMI percentile scores, which made a total of 34 pupils (29% of all participants). The findings of our study were slightly lower than the observed values by other authors, which range from 30% to 45% of overweight/obesity frequency in children (Guinhouya et al., 2009, Sanchez-Vaznaugh et al., 2015, Kolimechkov et al., 2017). The results from the health-related fitness tests showed that boys performed significantly better than girls, but the percentile scores in each fitness component were similar (Table 2).

The children from our study showed significantly higher results in lower body strength and cardiorespiratory fitness than the 50th percentile ($p < 0.05$) of the international norms for children. As shown on Table 2, the mean PRs for those tests in the boys and girls were around the 60th percentile, which is above the average. In the other two tests, which assessed upper body strength and motor fitness, the participants from our study showed results which were sufficiently close to the 50th percentile of the international norms, and did not differ significantly from it. The children with normal weight from our study showed a healthier profile in terms of their anthropometric parameters, and performed significantly better in the standing long jump, 4x10m shuttle run, and the 20m multistage fitness tests, in comparison with those who were assessed as 'overweight' or 'obese' (Table 3).

The results of this study showed that overweight and obese primary school children are associated with lower levels of health-related physical fitness. Excessive weight, above the WHO norms, limited fitness performance, and therefore tracking and assessing physical fitness, in addition to promoting

physical activity, should start from an early primary school age.

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