Obesity & Weight Loss Therapy

Research Article Open Access

Relationship between Physical Fitness and Nutritional Status in a Portuguese Sample of School Adolescents

Filipe Soares Ferreira*
Frei Heitor Pinto Grouping Schools, Covilha, Portugal

Abstract

The presence of overweight and obesity in children and adolescents it's real. Although there is a trend toward the decrease in physical fitness levels, the intensity of this decrease due to the nutritional status in adolescents is not well-known, particularly in school adolescents of inner Portuguese regions. The aim of this study is to describe physical fitness levels, nutritional status and analyze their association in school adolescents of Castelo Branco district, according to gender.

Cardiorespiratory fitness (20 meters shuttle run test), muscular fitness (curl ups, pushups and back arch tests) and nutritional status (body mass index) were carried out in 924 school adolescents (429 males and 495 females) aged between 12 and 17 years old. Descriptive, correlation and covariance analyses were performed. The prevalence ratio was analyzed thought Poisson regression.

For males and females, the overweight prevalence was 15.6% and 19.2%, respectively. Obesity prevalence was 5.1% for males and 3.8% for females. In both genders, low performances on cardiorespiratory and muscular fitness were found. Curl-ups and back-arch tests are in accordance to healthy fitness zone. Overweight and obese adolescents achieved low cardiorespiratory and muscular fitness levels. No differences were found on back-arch test between body mass status groups. Opposite correlations were found between physical fitness tests with BMI, excepting back-arch test. The prevalence ratios expose a strong trend toward the decrease of physical fitness tests in overweight and obese adolescents.

Assessing physical fitness and nutritional status in school adolescents is essential to primary prevention of century diseases. This study alert health care professionals to find and promote solutions that lead young people to be more active and healthy.

Keywords: Physical fitness; Nutritional status; Adolescents

Introduction

The World Health Organization classifies overweight and obesity the fifth leading risk for global deaths [1]. If no action will be taken to prevent them, they will have an epidemic proliferation and 50% of the population in 2025 will be overweight or obese. Once considered a high-income country problem, overweight and obesity are now on the rise in low and middle income countries, particularly in urban settings. A recent European report [2], which covers 36 countries, shows that the prevalence of overweight (including obesity) in adolescents ranges from 5% to more than 25%, demonstrating that the higher prevalence of obesity was found in Malta (30% for boys and 25% for girls) and lowest in the Nederland's (5% for boys and 7% for girls). In Portugal, its prevalence is estimated at 25% for boys and 23% for girls. We believe that adolescents with behavioral, biological, social and cultural predisposition to be sedentary, overweight and obese deserve special attention.

The increase of body fat and low levels of physical fitness, especially in adolescence, are associated with all-cause to cardiovascular mortality, in adulthood [3]. On the other hand, from a public health perspective, improvement of nutritional status and physical fitness can be an important tool for youth well-being improvement and diseases prevention [4]. It is noteworthy that some studies show that physical fitness is a stronger indicator of the individual health status compared to regular physical activity [5-7]. For us, prevent the obesity progression, achieving optimal levels of physical fitness, namely cardiorespiratory and muscular fitness are determinant factors to promote.

Excessive fatness (determined by body mass index (BMI) - a useful surrogate of percentage body fat) is found to be negatively associated with performance tasks [8]. A more detailed assessment of how this process occurs, during the adolescence, in different regions, can expose vital points for primary interventions, namely exercise and healthy eating habits. The significant increase in body mass combined with a sedentary lifestyle is associated with a decreased physical fitness, leading to impairments in cardiorespiratory function and muscle resistance [9].

Studies approaching the relationship between physical fitness and nutritional status in adolescents have been widely explored [8-14] however, general ignorance of its expression in Portuguese territory still persists, namely in inner regions. Therefore, the aim of this study was to describe and discuss the associations between body mass index (BMI) and physical fitness in Portuguese school adolescents aged 12-17 years of Castelo Branco district.

Material and Methods

Study population

This study was carried out with 924 adolescents (429 male and 495 female) who were all Caucasians aged 12 to 17 from 16 public schools in a Portuguese district (Castelo Branco). All adolescents were apparently healthy and free of any treatment. This study was conducted with the approval of the local ethic commission and after the written informed consent of the adolescents' parents.

***Corresponding author:** Filipe Soares Ferreira, Frei Heitor Pinto Grouping Schools, Covilha, Portugal, E-mail: lipesf@gmail.com

Received Jul 20, 2013; **Accepted** Sep 10, 2013; **Published** Sep 13, 2013

Citation: Ferreira FS (2013) Relationship between Physical Fitness and Nutritional Status in a Portuguese Sample of School Adolescents. J Obes Weight Loss Ther 3: 190.doi:10.4172/2165-7904.1000190

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Anthropometric variables

For each subject, the following anthropometric measures were gathered: weight, height and body mass index (BMI). The measurements of all subjects were carried out along a two consecutive week period between 9:00 am and 11:00 am. All measurements were collected by the author of the study.

Weight was determined with an electronic device (Tanita UM70, resolution of 0.1kg), and height was assessed with a portable stadiometer (resolution of 1mm). Subjects were measured dressing only a t-shirt and shorts, with bare feet, and in the orthostatic position, following the recommendations described elsewhere [15,16]. For each subject, the mean of three consecutive measurements was used for further statistical analysis.

BMI (kg/m^2) was determined through the division of the subjects' weight (kg) by the square of their height (m). Students were classified into three body mass categories (i.e., normal, overweight and obese) based on the International Obesity Task Force (IOTF) age and gender-specific definitions [17]. For us, the selection of IOTF classification was related to the international reference standards by compiling data from 6 heterogenous countries (Brazil, Great Britain, Hong Kong, The Nederland's, Singapore and the United States of America), that can be extrapolated to other countries, and by projecting the percentile curves through the adult cutoff points at the age of 18 years old [2,17,18].

Physical fitness tests

Fitness measurements were realized one week after the anthropometric measurements. All measurements were realized by the study's author collaborated by physical education teachers of the visited schools.

For cardiorespiratory fitness assessment students completed Leger 20 meter shuttle run test (20 m-SRT) [19] during physical education class (Figure 1).

Students run back and forth between two lines 20 meters apart in the school gymnasium at a progressively increasing pace, set by an audio-recorded beep, until they were no longer able to maintain the pace, or they voluntarily stopped running. The 20 m-SRT score was equivalent to the number of laps recorded when a student failed to reach within two strides of one of the end lines two consecutive times, or when they voluntarily stopped running. Maximal effort was encouraged by verbal prompting from researcher and classmates.

To measure muscular fitness three tests of the FITNESSGRAM® battery test were used [20] (Figure 2). All procedures for this tests are describe by Welk and Meredith [20].

Tests included curl ups, back arch and pushups. For curl ups and pushups tests the maximum number of repetitions (1 RM) was collected. For back arch measurements, the distance (cm) between the chin and the floor was gathered. Students completed muscular fitness tests during physical education class.

Cardiorespiratory and muscular fitness levels were categorized according to FITNESSGRAM® criterion-referenced health standards [20] (Table 1).

There are several types of standards commonly used with fitness tests. The FITNESSGRAM® uses a healthy fitness zone to designate the range of fitness scores associated with good health scores falling below the healthy fitness zone are categorized as needs improvement to indicate that efforts are needed to bring the score into the healthy fitness zone.

Statistical analysis

Descriptive statistical analyses were carried out considering means, standard deviations, confidence intervals and low physical fitness prevalence's. The data normality was confirmed by the Kolmogorov-Smirnov test. To analyze possible associations among variables, Spearman's correlations tests were used for interval-like and nominal variables. The criteria used by Malina [21] were used for the analysis of the correlations, which describe a low correlation for a value <0.30, a moderate correlation for values between 0.30 and 0.60 and high correlation for values >0.60. Covariance analysis (Ancova) was used to verify possible differences between physical performance means at different nutritional status, adjusted by gender and age. Poisson regression analysis was used to estimate the prevalence ratios considering the low physical fitness as the dependent variable, as the outcomes present high prevalence values [22]. The statistical significance level was set at 5% for all analyses.

Results

Means and standard deviations of study variables by nutritional status group and gender are presented in Table 2 and 3, respectively.

Overweight and obese adolescents achieved lower cardiorespiratory fitness and muscular fitness based on 20m-SRT, curl ups and pushups, respectively, compared with normal weight adolescents ($p<0.05$) (Table 2). No significant differences were found on back arch test between body mass status group (Table 2) ($p>0.05$).

Males and females obtain statistical differences in all measures (Table 3).

For all sample, BMI was significantly different between genders (0.05). The prevalence of overweight for males was15.6% and 19.2% for females. For obesity the prevalence was 5.1% for males and 3.8% for females.

Males and females exhibited low cardiorespiratory fitness (males mean=47.65 ± 22.75 laps completed, healthy fitness zone 48 to 85 laps; females mean=28.14 ± 12.37 laps completed, healthy fitness zone 28 to 49 laps) and muscular fitness, based on pushups test (males mean=14.66 ± 10.36 repetitions completed, healthy fitness zone 15 to 30 repetitions; females mean=8.11 ± 7.22 repetitions completed, healthy fitness zone 7

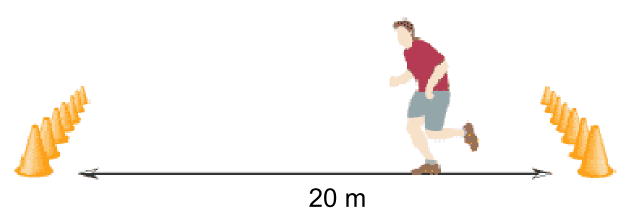

Figure 1: Leger 20 meter shuttle run test.

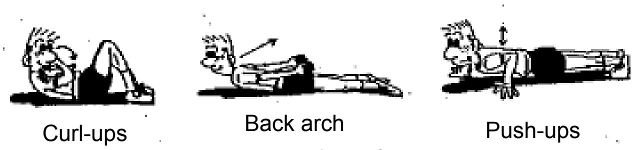

Figure 2: Muscular fitness tests.

Test	20m-SRT (laps)		Curl ups (1 RM)		Push ups (1 RM)		Back arch (cm)	
	Males							
Age (years)	Low	High	Low	High	Low	High	Low	High
12	32	72	18	36	10	20	23	30
13	41	72	21	40	12	25	23	30
14	41	83	24	45	14	30	23	30
15	51	94	24	47	16	35	23	30
16	61	94	24	47	18	35	23	30
17	61	94	24	47	18	35	23	30
Females								
Age (years)	Low	High	Low	High	Low	High	Low	High
12	23	41	18	32	7	15	23	30
13	23	51	18	32	7	15	23	30
14	23	51	18	32	7	15	23	30
15	23	51	18	32	7	15	23	30
16	32	51	18	32	7	15	23	30
17	41	51	18	32	7	15	23	30

20 m-SRT: 20 meters Shuttle Run Test; 1 RM: One Maximal Repetition

Table 1: FITNESSGRAM® Healthy fitness zones.

	Normal (N=724)		Overweight (N=161)		Obesity (N=39)		One-way Anova	
Variable	Mean	SD	Mean	SD	Mean	SD	F	p
Age (y)	14,06	1,42	14,18	1,54	14,97	1,46	7,55	<0,05
Weight (kg)	52,44	8,31	67,86	8,25	82,28	15,89	383,54	<0,05
Height (cm)	163,70	8,98	164,57	8,89	162,54	12,25	0,98	0,375
BMI (kg/m^2)	19,47	1,93	24,99	1,43	30,93	3,52	1073,16	<0,05
20m-SRT (laps)	39,93	20,73	27,52	15,35	26,54	17,36	31,86	<0,05
Curl ups (1 RM)	38,99	23,14	32,92	21,06	25,13	22,82	10,53	<0,05
Push ups (1 RM)	11,82	9,47	9,05	9,19	7,36	6,56	9,18	<0,05
Back arch (cm)	26,34	5,09	25,94	5,52	27,28	4,75	1,13	0,325

SD: Standard Deviation; BMI: Body Mass Index; 20 m-SRT: Shuttle Run Test; 1 RM: One Maximal Repetition.

Table 2: Descriptive statistics of al study variables, according to nutritional status.

	Males								Females							
	All sample (N=429)		Normal (N=340)		Overweight (N=67)		Obesity (N=22)		All sample (N=495)		Normal (N=381)		Overweight (N=95)		Obesity (N=19)	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (y)	14,33*	1,52	14,41*	1,52	13,97	1,44	14,09	1,60	13,94	1,37	13,96	1,33	13,73	1,38	14,63	1,86
Weight (kg)	59,08*	13,01	54,96*	9,42	71,34*	9,86	85,32	15,32	54,05	10,14	50,39	6,87	64,09	5,98	77,32	15,94
Height (cm)	168,15*	9,55	167,88*	9,62	169,80*	9,13	167,35*	9,62	160,03	6,76	160,04	6,48	160,43	6,02	157,71	13,07
BMI (kg/m^2)	20,76*	3,60	19,37	1,99	24,64	1,72	30,35	3,91	21,06	3,49	19,61	1,99	24,89	1,73	30,82	3,49
20m-SRT (laps)	47,65*	22,75	52,05*	22,02	32,30*	16,35	26,41	18,49	28,14	12,37	29,61	12,17	23,25	11,45	23,05	13,81
Curl ups (1 RM)	41,35*	23,76	43,18*	23,39	36,48*	24,05	28,00	23,27	33,87	21,78	35,60	22,14	29,19	18,51	22,58	23,89
Push ups (1 RM)	14,66*	10,36	15,76*	10,29	11,67*	10,01	6,73	6,94	8,11	7,22	8,62	7,39	6,42	6,44	6,26	6,16
Back arch (cm)	26,24*	5,02	26,08	5,25	26,84	4,14	26,95	3,58	26,37	5,28	26,45	5,04	26,00	6,01	26,63	6,21

SD: Standard Deviation; BMI: Body Mass Index; 20m-SRT: Shuttle Run Test; 1 RM: One Maximal Repetition; *Significant difference between genders (p<0.05).

Table 3: Descriptive statistics of study variables, according to nutritional status, for both genders.

to 15 repetitions). The muscular fitness, based on curl ups test (males mean=41.35 ± 23.76 repetitions completed, healthy fitness zone 23 to 44 repetitions; females mean=33.87 ± 21.78 repetitions completed, healthy fitness zone 18 to 34 repetitions) and back arch test (males mean=26.24 ± 5.02 cm, healthy fitness zone 23 to 30 cm; females mean=26.37 ± 5.28 cm, healthy fitness zone 23 to 30 cm) exhibited good values in accordance to the healthy fitness zone.

Table 4 shows the correlation results between physical fitness tests with BMI. Significant low to moderate inverse correlations was found in 20m-SRT test, curl ups and pushups, in both genders, except in back arch test.

Table 5 presents the differences in physical fitness tests according to BMI, for both genders, considering age adjustment. Significant differences for 20m-SRT, curl ups and pushups were found. No significant differences were found in back arch.

Table 6 presents the prevalence ratios for low physical fitness, according to BMI, for both genders. Strong and significant trend toward the decrease in physical fitness tests (20 m-SRT, curl ups and pushups) for overweight and obesity, for both genders was found. According to nutritional status, the highest prevalence ratio was observed for 20 m-SRT with overweight/obese individuals. Males and females presented physical fitness low ratios 5.91 and 2.94, respectively. The prevalence ratios are fold higher when compared with normal BMI.

Variables	Males (n=429)		Females (n=495)	
	BMI		BMI	
	R	p (b)	r	p (b)
20 m-SRT (laps)	-0,4	<0,05	-0,259	<0,05
Curl ups (1 RM)	-0,151	<0,05	-0,132	<0,05
Push ups (1 RM)	-0,237	<0,05	-0,159	<0,05
Back arch (cm)	0,058	0,232	-0,002	0,972

BMI: Body Mass Index; 20m-SRT: 20 meter Shuttle Run Test; 1 RM: One Maximal Repetition; (b): Spearman Correlation.

Table 4: Correlations between physical fitness test and body mass index.

Variables	Males			Females				
	Normal	Overw./Obese	Ancova	Normal	Overw./Obese	Ancova		
			F	p			F	p
20m-SRT (laps)	52,1 (22)	31,1 (17,3)	66,6	<0,05	29,7 (12,2)	23,1 (11,6)	27,3	<0,05
Curl ups (1 RM)	43,1 (23,4)	34,9 (24,1)	8,7	<0,05	35,5 (22,2)	28,7 (19,8)	9,2	<0,05
Push ups (1 RM)	15,8 (10,3)	10,6 (9,7)	14,7	<0,05	8,7 (7,4)	6,3 (6,4)	9,7	<0,05
Back arch (cm)	26,1 (5,3)	26,9 (4)	2,4	0,123	26,4 (5,1)	26,1 (5,9)	0,3	0,590

20m-SRT: 20 meter Shuttle Run Test; 1 RM: One Maximal Repetition.

Table 5: Covariance analysis of the physical fitness variables according to the nutritional status, adjusted for age, in both genders.

Variables	Males				Females			
	n	%	PR (IC95%)	P-value*	n	%	PR (IC95%)	P-value*
	20m-SRT							
Normal	132	39,1	1	<0,05	138	36,7	1	<0,05
Overweight/Obese	72	79,1	5,91 (3,41-10,26)		75	63	2,94 (1,92-4,51)	
	Curl ups							
Normal	78	23,1	1	<0,05	92	24,5	1	<0,05
Overweight/Obese	33	36,3	1,90 (1,15-3,12)		40	33,6	1,56 (1,00-2,44)	
	Push ups							
Normal	157	46,4	1	<0,05	167	44,4	1	<0,05
Overweight/Obese	66	72,5	3,04 (1,83-5,10)		75	63	2,13 (1,40-3,26)	
	Back arch							
Normal	81	24	1	0,129	80	21,3	1	0,895
Overweight/Obese	15	16,5	0,63 (0,34-1,15)		26	21,8	1,03 (0,63-1,71)	

(*) non adjusted p value (Chi-Square p value); 20 m-SRT: 20 meter Shuttle Run Test; PR: Prevalence Ratio.

Table 6: Prevalence and prevalence ratios (PR) for low physical fitness, according to nutritional status, for both genders.

The prevalence ratios showed a similar behavior when the performance at the curl ups and pushups muscular fitness tests was analyzed.

Discussion

The literature is very clear about the lack of consensus to define and classify youth overweight and obesity. This has also reinforced that the extrapolation of obtained values in other studies for a specific population with its particular characteristics, may not be the best methodology. So, to know the reality of each population further epidemiological studies are required. This community-based study permitted us to analyze various anthropometric measures for a large proportion of Castelo Branco adolescents. Few previous representative studies [23] have collected such broad data on nutritional status and physical fitness levels in this region. This knowledge will promote the development of interventions to prevent obesity and other related diseases. We also believe that this study will develop policy interventions to meet the requests of young population.

The present study provides data on the prevalence of overweight and obesity among adolescents, and the association between nutritional status and physical fitness separately for males and females aged between 12 to 17 years old from Castelo Branco district. Nutritional status is an important component of physical fitness of an individual and provides an well-being indicator [4], hence should be emphasized as a way of healthy lifestyle among adolescents in this area. The present findings reflect the existence of overweight and obesity in males (15.6%/5.1%) and females (19.2%/3.8%), respectively. It can be argued that overweight and obesity values found in adolescents of Castelo Branco are consistent with the high levels of overweight and obesity found in the Mediterranean countries, which prevalence values are between 20 and 40% [24]. Most studies prefer to use BMI as a nutritional status criterion measure, independently of its limitation to measure body fat [25]. The selection of BMI is related with the easy application, low costs and the possibility to collect a larger number of data. In studies that involve large populations, the literature also supports BMI to diagnose nutritional status [26-28].

The prevalence ratios confirmed the strong trend toward the decrease in physical fitness among individuals with overweight and obesity. This result means that participants with reduced levels of physical fitness are overweight and obese. Nonetheless, this analysis identified a higher relevance of the nutritional status for low cardiorespiratory fitness levels, when compared to other physical capacities. It should be noted that the consequences of obesity is reported to be related to reduce health-related physical fitness [8]. According to our results, we don't observe any significant association between back arch test and BMI. However, other studies have shown that performances in back arch tests had an inverse association with BMI [29]. From our point of view the back arch test can also be used to evaluate the flexibility of the trunk. The association of the component flexibility with BMI is scarce, which is difficult to carry out a more detailed comparison of our results.

With regard to the physical fitness, males had higher performance in 20 m-SRT, curl ups and pushups tests. Females had higher performance in back arch test. These results are consistent with other study [30], finding that generally males exhibit better results, in the most physical activity tests, than females. The differences found between genders in physical fitness tests may be explained in part by differences in body composition. For example, it's common males exhibit greater muscle density and fewer body fat compared to girls, at the same age group [31].

After analysis of the mean values between the different tests performed by our sample and the values of the FITNESSGRAM® healthy fitness zone [32], we observed that for both gender, mean values of 20 m-SRT and pushups tests, are very close to the lower limit of healthy fitness zone. In curl ups and back arch tests our sample present values within the healthy fitness zone. According to nutritional status overweight and obese adolescents presented worse results in 20 m-SRT, curl ups and pushups tests. The correlation analysis indicates that cardiorespiratory and muscular fitness tests have an inverse and significant association with BMI. These results are in agreement with previous studies [29,33]. Although the mechanism by which high cardiorespiratory and muscular fitness reduces the hazard risk of obesity is not clear.

It should be realized that the current study has some limitations which requires caution in the interpretation of the data. It should be noted that physical fitness is a function of both physical activity and non-modifiable factors such as genetics and these factors were however not assessed in the present study and therefore, it was impossible to assess their relative contribution. Maturation may one way or the other has affected the results; unfortunately no reliable data on maturation could be collected within the present study.

One strong point of this study is that measured, rather than reported, heights and body mass were obtained from adolescents, eliminating body mass classification based on biased reporting. This paper also offers a strong contribution to guide future investigations in other regions, because of it high practicability and experimental feasibility. However, we are aware that the cross sectional data collection method, does not exclude the reversibility of causal relationships analyzed. For this reason, with the planned longitudinal study we will be able to determine whether the observed prevalence of underweight and overweight as well as its relationship with physical fitness adjusted for other possible confounding factors, such as habitual physical activity, genetics factors, socio-economic status, dietary intake and other modifiable risk factors are consistent overtime, and whether the changes in body composition measurements of BMI, waist circumference and body fat percentage are related to changes in physical fitness.

Conclusions

In opinion, assessing physical fitness and nutritional status in adolescents is essential to primary prevention of century diseases. For example, this study reveals the importance of physical fitness components to identify and change behaviors that can facilitate and aggravate obesity in young people. As demonstrated, in the adolescence the obesity is real and we believe that this is the ideal time to create a healthy lifestyle. School is the place where young people spend more time, reason why they can initiate healthy lifestyle practices, with the predominant contribution of physical education. In this context, it is recommended that Schools assumed the contribution of physical fitness and nutritional status evaluation in the primary prevention of related diseases.

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