Journal of Exercise Physiologyonline

February 2022
Volume 25 Number 1

Official Research Journal of the American Society of Exercise Physiologists

ISSN 1097-9751

JEPonline

Nutritional Status and Aerobic Fitness in Chilean Adolescents

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ABSTRACT

Urzua-Alul L, Vidal-Espinoza R, Gomez-Campos R, Fuentes-Lopez J, De La Torre Choque C, Gomez-Campos G, Cossio-Bolaños M. Nutritional Status and Aerobic Fitness in Chilean Adolescents. **JEPonline** 2022;25(1):56-67. The purpose of this study was: (a) to analyze the nutritional status and aerobic fitness in Chilean adolescents; and (b) to verify the association between the two variables in a sample of Chilean adolescents. The study was a descriptive cross-sectional analysis of 155 adolescents (72 males and 83 females) from the province of Talca (Chile). The age range was 14 to 16 years. Weight, height, waist circumference, and two skinfolds (tricipital and subscapular) were evaluated. Body mass index (BMI) was calculated and the two skinfolds were summed (Σ(Tr+Sb). Aerobic fitness was measured by cardiopulmonary exercise test (TECP) in the laboratory. The males' nutritional status consisted of 44.5% normal weight, 13.8% overweight, and 41.7% obese. In the females, 45.8% were normal weight, 26.5% were overweight and 27.7% were obese. In aerobic fitness, 94.4% of the males were unhealthy and 5.6% were healthy, while 92.37% of the females were unhealthy and 7.3% were healthy. In general, in both sexes there was a significant association between both variables (X^2 = 13.17, $P<0.05$). High prevalence of overweight, obesity, and unhealthy aerobic fitness was verified, and an association between nutritional status categories and aerobic fitness levels was observed in adolescents of both sexes. The results suggest promoting in adolescents not only a healthy weight, but also a physically active lifestyle to counteract the deterioration of their aerobic performance and well-being.

Key Words: BMI, Exercise, Metabolism, VO_2 Max

INTRODUCTION

Adolescence is a period of rapid growth and development, second only to childhood, due to biological and psychological changes, often shaped by sociocultural factors (4). During this stage of life, both nutritional status and physical fitness play a relevant role in preserving the health of this population.

Nutritional status refers to the situation in which a person is in relation to intake and the physiological adaptations that take place after nutrient intake (6). In fact, nutrition is a basic human need and a prerequisite for a healthy life, especially during the period of growth and development while a nutritional deficit affects body size, resulting in short stature or thinness (23). On the other hand, an excessive intake of nutrients (i.e., overnutrition) in adolescents is associated with chronic diseases and mortality later in life (29). Hence, the current scientific evidence suggests that a healthy weight should be maintained not only in adolescence, but throughout life (12,42).

Overall, the prevalence of overweight and obesity among people of all ages worldwide has increased considerably over the past two decades (11). This global epidemic has important consequences, including for example an increased risk of developing non-communicable diseases (NCDs) in adulthood (11) and even, several studies (3,18,22,28,31) have shown that youth fitness is negatively related to increased BMI and body fat mass. Consequently, an increase in the percentage of overweight and obese adults worldwide (30) and especially in Chile with overweight at 39.8% and obesity at 31.2% (26), an increase in aerobic exercise and fitness levels in Chilean adolescents could reflect an increase in longevity.

In fact, aerobic fitness is considered a protective factor for cardiovascular diseases such as type 2 diabetes mellitus, hypertension, atherosclerosis, and metabolic syndrome (40). Hence, it is important to understand the nutritional status and aerobic fitness of adolescents, since the prevalence of a low level of aerobic fitness and obesity increases morbidity and mortality in adulthood (34). Therefore, the purpose of this study was to analyze the prevalence of nutritional status and aerobic fitness and to verify the association between these variables in a sample of Chilean adolescents.

METHODS

Type of Study and Sample

A descriptive cross-sectional study that consisted of 155 adolescents (72 males and 83 females) was carried out in the province of Talca (Chile). The age range was 14 to 16 years.

The sample selection was non-probabilistic (convenience). Schoolchildren from a municipal school in the city of Talca were invited to participate on a voluntary basis during the months of April and May of 2017. The parents were previously informed about the objective of the project, who then authorized the informed consent of their children.

The schoolchildren who signed the informed consent and who completed the anthropometric and aerobic fitness measurements were included. Adolescents who reported some common respiratory diseases (e.g., pharyngitis, tonsillitis, rhinitis, and/or bronchitis) a month prior to the study getting underway were excluded. This study was approved by the Local Ethics Committee with protocol number Universidad Autonoma de Chile UA-104-17, and developed according to the recommendations of the Helsinki declaration for human subjects.

Techniques and Procedures

Anthropometric data, such as weight, height, waist circumference, and skinfolds (triceps and subscapular) were evaluated following the suggestions of the International Society for the Advancement of Kinanthropometry. Body weight (kg) was measured with a scale (SECA, Hamburg) with an accuracy of 0.1 kg. Height was measured, keeping the head in the Frankfurt plane, with a stadiometer (SECA, Hamburg) to the nearest 0.1 cm. Waist circumference (WC) was assessed with a Seca metal tape measure graduated in millimeters with an accuracy of 0.1 cm. in millimeters with an accuracy of 0.1 cm. Skinfolds (triceps and subscapular) were assessed on the right side of the body using a Harpenden caliper (British Indicators, Ltd., London) exerting a constant pressure of 10 $g \cdot mm^{-2}$.

Body mass index BMI ($kg \cdot m^{-2}$) was calculated for both sexes and the two skinfolds [tricipital + subscapular (mm)] were summed. To classify BMI by nutritional categories, the cut-off points of the World Health Organization (10) were used: p10 to p85 normal, p85 to p95 overweight, and p95 obese. To assess aerobic fitness, the participants were asked: (a) to refrain from vigorous physical exercise for 24 hours prior to the test; and (b) to eat their food at least 3 hours before the submaximal test. A 10-minute warm-up combined with flexibility exercises was performed beforehand. Direct measurement of VO_2 max was performed using a treadmill (H/P Cosmos Mercury) with a running surface 150 X 50 cm at a speed from 0 to 22 $km \cdot hr^{-1}$ with an elevation from 0 to 24% using a long handrail. An ultima CPX™ metabolic stress testing system (Medical Graphics Corporation, St. Paul, MN) was used in conjunction with Breeze Gas Suite 6.4.1 software.

The Bruce protocol was used to measure peak oxygen consumption (VO_2 max) in $L \cdot min^{-1}$ and VO_2 max in $mL \cdot kg^{-1} \cdot min^{-1}$ according to suggestions described by the American Thoracic Society (2) and the American College of Chest Physicians (35). Peak oxygen consumption was obtained using the cardiopulmonary exercise test (TECP). All tests were performed by a single evaluator with extensive experience and were performed in an enclosed laboratory at 22 to 24°C. Each participant was fitted with a mouthpiece, a two-way nonbreathing valve (Hans Rudolf model 2700B, Kansas City, MO), and a nose clip to allow measurement of expired gases. Heart rate (HR) was measured and recorded continuously with an electronic HR monitor (Polar, Inc.) that was worn by the participant. During each stage of the test, the participant reported a rating of perceived exertion using a zero to 10-point scale.

This test consisted of an increase in incline and speed every 3 minutes. The periods of time when speed and incline remained constant are referred to as stages. The duration of the stress test for a normal person is approximately 8 to 12 minutes. The goal of the test was to obtain the heart rate at approximately 80% of the predicted maximum (220-Age) at the end of the stress test. To ensure that each adolescent achieved maximal exertion, four criteria were considered: (a) a peak plateau in VO_2 with an increase in exercise intensity; (b) a respiratory quotient of at least 1.15; (c) a maximal respiratory rate of at least 35 breaths·min^{-1}; and (d) an exertional perception rating of at least 10 units on the Borg scale. Aerobic fitness status was categorized according to the cut-off points described by Cureton and Warren (9) and the Cooper Institute: Males 12 to 19 years of age (healthy >42 mL·kg^{-1}·min^{-1}) and females 14 to 19 years of age (healthy: >35 mL·kg^{-1}·min^{-1}).

Statistical Analysis

Descriptive statistical analysis was performed for arithmetic mean, standard deviation, and range. Differences between sexes were verified by Student's *t*-test for independent samples. Comparisons between categories of nutritional status (normal weight, overweight, and obese) were performed by one-way ANOVA and Tukey's test of specificity. Chi-square analysis was used to verify the association between BMI nutritional categories with aerobic fitness status (healthy and unhealthy). In all cases, statistical significance $P<0.05$ was adopted. All the data were analyzed using SPSS 18.0.

RESULTS

The variables characterizing the sample studied are shown in Table 1. Men presented higher values of weight, height, aerobic fitness (L·min^{-1}, mL·kg^{-1}·min^{-1}, distance and time) compared to women ($P<0.05$), while women reflected greater adipose tissue in the tricipital and subecapular folds than men ($P<0.05$). There were no differences in age, waist circumference, and BMI.

Table 1. Anthropometric Characteristics and Aerobic Fitness Performance of the Studied Sample.

Variables	Men (n = 72)			Women (n = 82)			P
	M	±	SD	M	±	SD	
Age (yrs)	14.79	±	0.56	14.89	±	0.58	0.055
Anthropometry							
Weight (kg)	67.83	±	11.14	62.02	±	9.65	0.001
Height (cm)	168.1	±	5.72	159.1	±	6.22	0.000
Tricipital Fold (mm)	18.50	±	10.54	23.73	±	10.8	0.002
Subscapular Fold (mm)	17.06	±	9.37	20.86	±	10.2	0.014
Σ(Tr+Sb) (mm)	35.56	±	19.33	44.95	±	20.2	0.004
C. Waist (cm)	78.79	±	9.66	78.25	±	8.93	0.717
BMI (kg·m^{-2})	23.90	±	3.60	24.50	±	3.30	0.340
Aerobic fitness							
VO_2 max (L·min^{-1})	2.03	±	0.36	1.59	±	0.32	0.000
VO_2 max (mL·kg^{-1}·min^{-1})	31.20	±	9.12	26.43	±	6.72	0.000
Distance (m)	503.10	±	110.90	400.30	±	72.30	0.000
Time (min·sec^{-1})	7.10	±	1.20	368.20	±	80.30	0.000

M = Average; **SD** = Standard Deviation; **C** = Circumference; **Tr** = Tricipital; **Sb** = Subscapular; **BMI** = Body Mass Index

The prevalence by nutritional status and aerobic fitness of the adolescents are shown in Figure 1. In terms of aerobic fitness, there were no differences between the sexes (P=0.774). Both males and females presented similar proportions with a high percentage of unhealthy cases (between 93% and 94% for both sexes) and a low proportion of adolescents with healthy aerobic fitness (6% and 7%), respectively. In the prevalence of nutritional status, there were significant differences between both sexes, with the females showing a higher percentage of overweight cases (27%), while the males had a higher prevalence of obesity (42%). However, in the normal weight category, the percentages were similar with 45% in the males and 46% in the females.

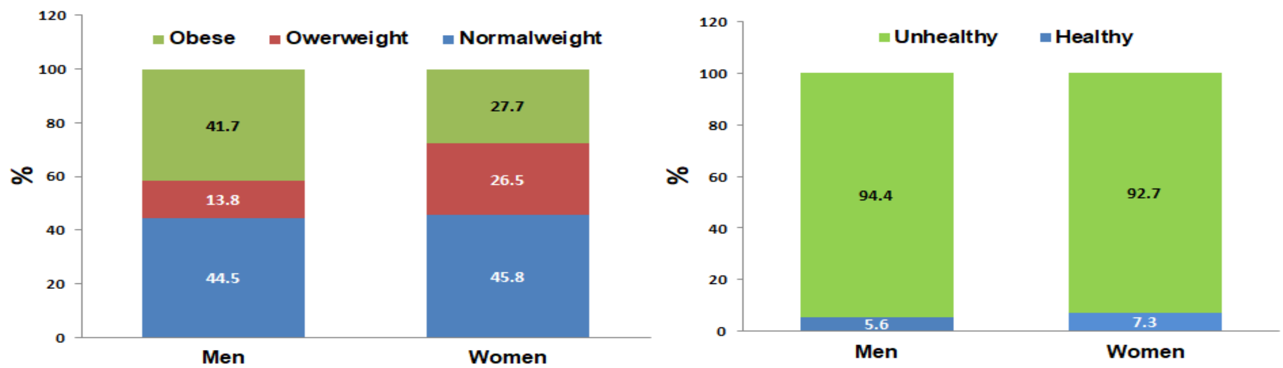

Figure 1. Comparison of the Prevalence of Nutritional Status (BMI) and Aerobic Fitness Levels (VO_2max) in Male and Female Adolescents.

The association between the categories of nutritional status and aerobic fitness are shown in Table 2. In both sexes, there was a significant association between both variables ($P<0.05$). The highest prevalence in the adolescents was observed in the group with unhealthy aerobic fitness (in males: 16.7% overweight and 41.7% obese, in females: 24.5% overweight and 28.0% obese). The lowest prevalence is observed in healthy aerobic fitness (corresponding to 5.5% of men and 7.3% of women with normal weight). In general, 38.1% of adolescents categorized as normal weight had unhealthy aerobic fitness compared to 55.3% who were overweight and obese, respectively.

Table 2. Association of Aerobic Fitness Levels with Nutritional Status Categories of Male and Female Adolescents.

Aerobic Fitness	Normal Weight n (%)	Overweight n (%)	Obese n (%)	Total n (%)	P-Value
Men					
Unhealthy	26(36.1%)	12(16.7%)	30(41.7%)	68(94.5%)	$X^2 = 5.93$
Healthy	4(5.5%)	0(0%)	0(0%)	4(5.5%)	P = 0.050
Women					
Unhealthy	33(40.2%)	20(24.5%)	23(28.0%)	76(92.7%)	$X^2 = 7.14$
Healthy	6(7.3%)	0(0%)	0(0%)	6(7.3%)	P = 0.028
Both Sexes					
Unhealthy	59(38.1%)	32(20.9%)	53(34.4%)	144(93.4%)	$X^2 = 13.17$
Healthy	10(6.6%)	0(0%)	0(0%)	10(6.6%)	P = 0.001

The comparisons of VO_2 max by nutritional categories in both sexes can be seen in Figure 2. In both men and women, those categorized as normal weight have better absolute and relative aerobic fitness in relation to those categorized as overweight and obese (except in the females between normal weight and overweight), in addition, the overweight adolescents have better aerobic fitness than the obese adolescents ($P<0.05$).

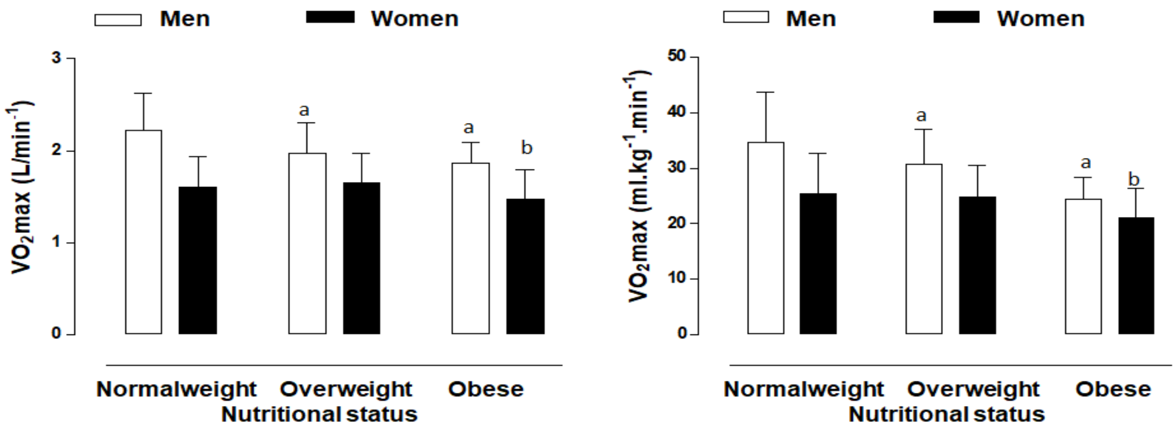

Figure 2. Comparison of Aerobic Fitness According to Nutritional Status Categories in Adolescents. Legend: **a** = SD in relation to normal weight in women; **b** = SD in relation to normal weight in men.

Figure 3 shows the comparisons of the anthropometric indicators (BMI, WC and Σ(Tr+Sb) according to healthy and unhealthy aerobic fitness status. In both sexes, there were significant differences in the three anthropometric indicators, where, adolescents categorized as healthy presented lower values of BMI, WC and Σ(Tr+Sb) in relation to the unhealthy ($P<0.05$).

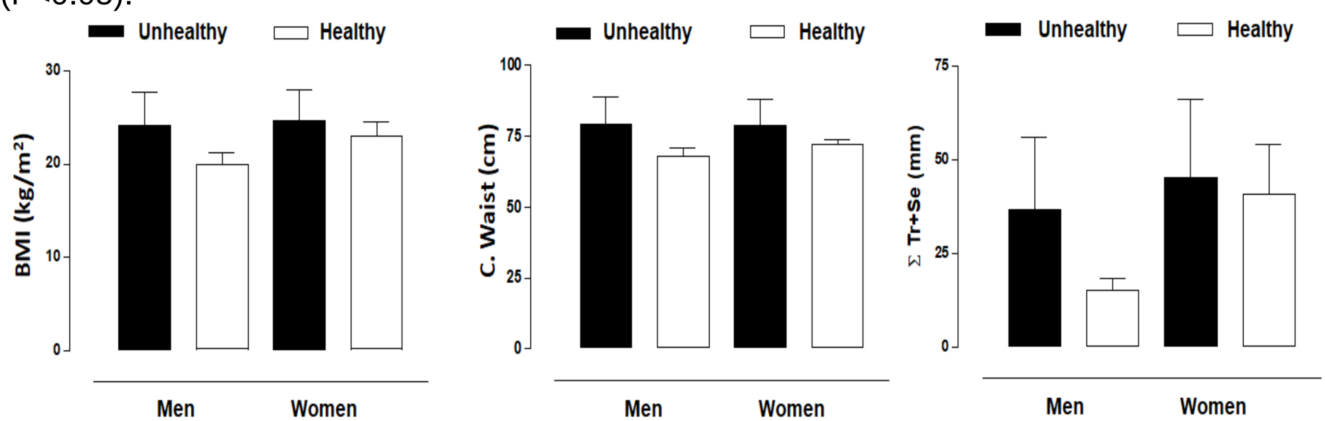

Figure 3. Comparison of Anthropometric Indicators According to Aerobic Fitness Levels in Adolescents.

DISCUSSION

The results of this study indicate that 38.1% of the Chilean adolescents were categorized as normoweight, 20.9% as overweight, and 34.4% as obese. The findings are relatively similar with other reports and/or studies conducted in Chilean adolescents (5,16,44). These findings confirm the accelerated increase of obesity in recent years in the Chilean population, as obesity increased from 23.2% in 2003 to 31.2% in 2017 and overweight increased from 37.8% to over 39% (26).

Regarding the prevalence of aerobic fitness, we observed that 94.4% of young people presented unhealthy aerobic fitness, while only 6.6% reflected healthy aerobic fitness. These results are alarming, since in recent years, several studies have documented that low levels of cardiorespiratory fitness are associated with a high risk of cardiovascular disease, all-cause mortality, and mortality rates attributable to various cancers (20,27,37). In fact, the prevalence of aerobic fitness observed in the present study are similar with some studies recently performed in Brazilian youth, evidencing 92.5% (39) and 89.1% of unhealthy aerobic fitness (13), while other studies developed in Europe and the United States reported unhealthy aerobic fitness around 30.9%, 45% and 52% (8,24), respectively.

In essence, after categorizing the findings by nutritional status (normoweight, overweight, and obese) and aerobic fitness (healthy and unhealthy), the results of this study indicate a significant association between both variables. Young people who were categorized as overweight and obese presented poor performance in their aerobic fitness and; consequently, they demonstrated a higher BMI and adipose tissue than the participants who were categorized as normoweight. These results in general confirm the association between categories of nutritional status with aerobic fitness levels in adolescents (3,31,43), so that young people categorized with high body fat values presented a lower maximal oxygen uptake (VO_2 max) (15). Statistically, it is possible that at a later age, these adolescents could develop cardiovascular diseases with a higher risk of premature mortality due to overweight and obesity (38).

However, it is also important to point out that the findings identified 38.1% of the adolescents categorized as normoweight presented unhealthy aerobic fitness. These findings are relevant, since young people who present adequate levels of body weight do not necessarily present healthy aerobic fitness. This confirms the findings obtained by some recent studies (32,33), whereby apparently individuals who are of normoweight also present unhealthy aerobic fitness and even low levels of physical activity. Therefore, practicing moderate to vigorous physical activity and at the same time presenting a healthy weight according to age and sex are determining factors to preserve aerobic fitness and good health (7). Maintaining an adequate level of aerobic fitness and musculoskeletal integrity can contribute to proper growth and development during childhood and adolescence (21). Moreover, improving physical exercise capacity, particularly cardiorespiratory fitness has been and remains to be an important lifestyle to reduce cardiovascular diseases (1).

Given the importance of achieving better nutritional status and aerobic fitness performance, the literature indicates that various strategies encompassing physical education classes, classroom activities, extracurricular sports, and active transportation are worth emphasizing to improve physical activity levels (14) aerobic fitness and reduce excess body weight (25). In essence, this study helps to support the scientific findings as well the value of the gold standard test of measuring aerobic fitness of adolescents. This test was performed until voluntary exhaustion, using direct measurement of maximal volume of oxygen consumption (VO_2 max) in a laboratory setting (27) and in addition, the values obtained in this study, both of the prevalence of the participants' nutritional status and aerobic fitness can serve as a baseline for future comparisons not only for health professionals, but also for researchers.

Limitations in this Study

It should be noted that the present study has some limitations that should be recognized. For example, the sample size and the cross-sectional design do not necessarily allow for generalizing the results obtained. Also, the definition of nutritional categories should be contrasted by gold standard methods, such as dual-energy X-ray absorptiometry (DXA). Future studies should consider extending the age range to cover the whole period of adolescence to better understand and verify the cause-effect relationship between physical activity, nutrition, disability, and disease.

CONCLUSIONS

Following the results obtained, this study demonstrated association between nutritional status categories with aerobic fitness levels in adolescents of both sexes. The alarming prevalence of overweight, obesity, and unhealthy aerobic fitness observed indicate the likelihood of adverse lifelong health consequences. The results suggest promoting not only a healthy weight, but also a physically active lifestyle in adolescents to counteract the decrease in aerobic performance, overall health, and well-being.

ACKNOWLEDGMENTS

The authors thank the children and adolescents for their participation.

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