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Rev Chil Pediatr. 2018;89(6):701-708
DOI: dx.doi.org/10.4067/S0370-41062018005001004

ORIGINAL ARTICLE

Relationship between body adiposity and horizontal jump in school children and adolescents

Relación entre adiposidad corporal y salto horizontal en niños y adolescentes escolares

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Received: 8-3-2017; Approved: 13-7-2018

Abstract

A high level of physical fitness in childhood and adolescence is associated with more favorable physical and mental health outcomes. **Objective:** To compare body adiposity and horizontal jump performance with international studies and to analyze the relationship between body adiposity and horizontal jump performance indicators in children and adolescents. **Patients and Method:** Descriptive study conducted on 812 adolescents from Talca (Chile), with an age range between 10.0 and 16.9 years. Weight, height, waist circumference (WC) and Horizontal jump (HJ) were evaluated after warm-up for 10 to 15 minutes to evaluate the explosive strength of the lower extremities according to the protocol of Castro-Piñero et al. Adiposity and HJ were compared with national and international studies. The data normality was verified by the Kolmogorov-Smirnov test. Smoothed percentile curves (p50) were created for BMI, WC, and HJ for each gender according to the LMS method. **Results:** Adolescents showed differences in body adiposity and HJ performance with international studies. In both genders, negative and significant correlations were found between the BMI and the HJ (men r = -0.104 and women r = -0.149) and between the WC and the HJ (men r = -0.100 and women r = -0.131). The adolescents who were classified in tertile 1 (good) and tertile 2 (satisfactory) had lower body adiposity (BMI and WC) and better HJ performance than those in tertile 3 (poor). **Conclusion:** Higher body adiposity and lower HJ performance were observed compared to international studies. In addition, a negative relationship between body adiposity and HJ was found. These findings suggest that the progressive increase of adiposity as age increases negatively affects the strength performance of the lower extremities of the studied children and adolescents.

Keywords:
Adiposity;
Adolescents;
Physical Fitness;
Muscular Strength

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Introduction

Fat tissue plays a complex regulatory role and exerts many of its effects on fat-free mass[1] not only in adults but also in children and adolescents. The content of adipose tissue and mainly the distribution of body fat are associated with increased risk of cardiovascular disease, obesity, type 2 diabetes, hypertension, among other diseases[2].

Several techniques are currently available to assess and/or determine body fat, including body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), waist-height ratio (WHTR), skinfold thickness, dual-energy x-ray absorptiometry (DXA), and hydrostatic densitometry[3]. Basically, these indicators belong to one of the components of physical fitness called morphological, which are commonly used to determine health-related physical fitness.

Studies have shown that a high level of physical fitness in childhood and adolescence is negatively associated with obesity, cardiovascular disease, skeletal and mental health[4]. These studies generically analyze the components of physical fitness in samples of children and adolescents, however, as far as it knows the specific associations between the evaluated muscle component through the horizontal jump (HJ) test with body fat has not yet been addressed in school adolescents in Chile. Studying this subject is relevant since in recent years the trend towards an increase in body fat has been gradually increasing among adolescents and young university students[6-7] respectively.

These observed trends could play a negative role in the physical performance of Chilean adolescents, which should be studied in depth transversally and/or longitudinally.

The specific approach of linking HJ to body fat may help to describe changes in body composition in children and adolescents, as excess adiposity may contribute negatively to the explosive power performance of the lower extremities. In addition, HJ is a muscular aptitude test, a field test that has a proven validity through isokinetic strength tests[8], and according to the literature, this test can be used not only in athletes, but also in non-athletes to relate to bone health[9], lipid profile, glucose levels, and body fat in children and adolescents[4].

Consequently, this study hypothesizes the existence of differences in body fat and HJ performance with international studies, and there could even be a negative relationship of high BMI and WC values on HJ performance in adolescents of both sexes. In addition, the focus of the relationship between body fat indicators and physical fitness includes the intact functioning of the musculoskeletal system, meaning that a group of muscles can generate strength to perform maximum and dynamic contraction in a group of muscles in a short period of time (explosive force), which could be impaired by excess weight of adipose tissue, especially in activities where body weight displacement is required.

The objective of this study was to compare body fat and performance in horizontal jumping with international studies and to analyze the relationship between indicators of body fat with horizontal jumping in school children and adolescents. Relevant information is expected to be obtained in order to provide objective recommendations during physical education classes[10].

Patients and method

Type of study and sample

Descriptive study. 812 children and adolescents between the ages of 10.0 and 16.9 were selected from six public schools in Talca (Chile), considered emblematic and with the largest number of students enrolled. The sample size was probabilistically calculated (stratified) from a universe of 5,880 students (95% CI), and 13.80% was obtained (485 men and 327 women). The number of sample elements of each stratum was directly proportional to the size of the stratum (age and sex) within the population.

Children and adolescents whose parents signed informed consent, assent (students) and those who attended on the day of the assessment were included in the study. Those who did not complete the tests and students who had some type of physical limitation that prevented them from taking the physical test were excluded. The whole study had the respective permissions of the administration of each school and the ethics committee of the Universidad Autónoma de Chile.

Procedures

Decimal age, anthropometric variables, and physical test were assessed using standardized procedures. The decimal age was calculated considering the date of birth (day, month, and year) and the evaluation date (day, month, and year). The anthropometric variables were assessed according to the protocol of the International Society for the Advancement of Kinanthropometry ISAK[11]. The weight (kg) was measured with a Tanita scale with 100g of accuracy and the height (cm) with a Seca stadiometer with 1mm of accuracy. Both instruments were calibrated according to the manufacturer's recommendations. The waist circumference (cm) was evaluated with a Seca measuring tape with an accuracy of 1mm. The Body Mass Index [BMI = weight (kg)/ height $(m)^2$] was used to relate weight-for-height.

Before evaluating the horizontal jump (HJ) test, a 10-15-minute warm-up was done, where the students

performed joint mobility and flexibility exercises. This test evaluates the explosive power of the lower extremities, for which the standardized protocol of Castro-Piñero et al[12] was followed. A Cardiomed nylon measure tape with a 0.1 cm accuracy was used. The teen jumps with both feet forward (shoulder width apart), trying to get as far as possible from the starting line (tip of the feet). Distance is obtained by measuring from the starting line to the heel closest to the line during landing. The procedure was carried out three times and the best result was recorded.

To compare body fat by means of the BMI, the American reference from CDC-2012[13] was used, as well as the reference from Brazil[14], and Argentina[15]. To compare the WC, the regional reference of Chile[16] and the American reference of CDC-2012[13] were used. For the performance of the HJ, the reference of Brazil[17] and Macedonia[18] was used. All studies used the LMS method to generate the percentiles and reflect them in smoothed curves.

Statistics

Data normality was verified through the Kolmogorov-Smirnov test. Descriptive statistics (arithmetic mean and standard deviation) were calculated. The differences between the two sexes were determined through T-test for independent samples. Smoothed percentile curves (p50) were created for BMI, WC, and HJ for each gender according to the LMS method[19]. This method uses the Box-Cox transformation (L) because the standard deviation tends to increase with age and is strongly dependent on the mean, a better estimate of variability is obtained with the coefficient of variation (S) and the median (M). To classify the HJ in categories (poor, satisfactory, and good) terciles were calculated. The differences between categories were determined by one-way ANOVA and post hoc Sheffé tests. In all cases, the significance level of 0.05 was adopted. Statistical calculations were made in Excel spreadsheets and in SPSS 18.0 software.

Results

Table 1 shows the anthropometric characteristics and HJ performance of adolescents of both sexes. Men showed higher height, waist circumference, and HJ in relation to women ($p < 0.05$). There was no difference in age, weight, and BMI ($p > 0.05$) (table 1).

Figure 1 shows the percentile comparisons of body fat (BMI and WC) with international studies and the American CDC-2012 reference. Adolescents in the study had higher BMI values (0.9 to 3.3kg/m^2) in relation to schoolchildren in Brazil and Argentina, however, the CDC-2012 reference is above all studies. In relation to the WC, men at early ages (10 to 12 years) showed similar values with respect to the CDC-2012 reference and the Chile regional study. The studied schoolchildren had lower values from 13 to 16 years of age. In the case of women, the values were relatively lower at all ages compared to the regional study of Chile (-0.5 to -2.0cm), in turn, these were well below the CDC-2012 reference (-1.0 to -4.0cm). Overall, in both sexes, BMI and WC values increased as age increased and were below the CDC-2012 reference mean values (figura 1).

Figure 2 shows the comparisons of HJ with international studies. Macedonian schoolchildren of both sexes were significantly better compared to the young people in the present study, surpassing between 4.7 and 22.9cm, however, when compared with the study in Brazil, the values were relatively similar at least in men, while in women they were similar between the ages of 10 and 16 (figura 2).

Table 2 shows the comparisons of BMI, WC, and HJ between terciles. In the case of body fat indicators (BMI and WC), significant differences were observed in the three groups and in both sexes. Children and adolescents placed in tercile 1 showed significantly lower values than the other two terciles ($p < 0.05$). In the case of HJ, men located in tercile 3, both for BMI and WC, had lower values, however, in women, this pattern was

Table 1. Characteristics of the sample studied

Variables	Men				Women				p
	X	SD	Mínimum	Máximum	X	SD	Mínimum	Máximum	
Age (years)	12.6	2.0	10.0	16.0	12.5	1.9	10.0	16.0	0.68
Weight (kg)	51.8	14.8	23.0	109.0	49.9	12.4	24.0	91.0	0.06
Height (m)	1.54	0.13	1.17	1.87	1.52	0.10	1.22	1.75	< 0.02
BMI (kg/m^2)	21.5	4.0	14.0	37.3	21.4	4.0	14.0	36.9	0.73
WC (cm)	74.5	10.8	35.0	113.0	71.4	9.6	53.0	112.0	< 0.001
HJ (cm)	145.6	31.8	67.0	244.0	120.6	19.4	57.0	178.0	< 0.001

X: Average, SD: Standard deviation, HJ: Horizontal jump, WC: Waist circumference, BMI: Body Mass Index.

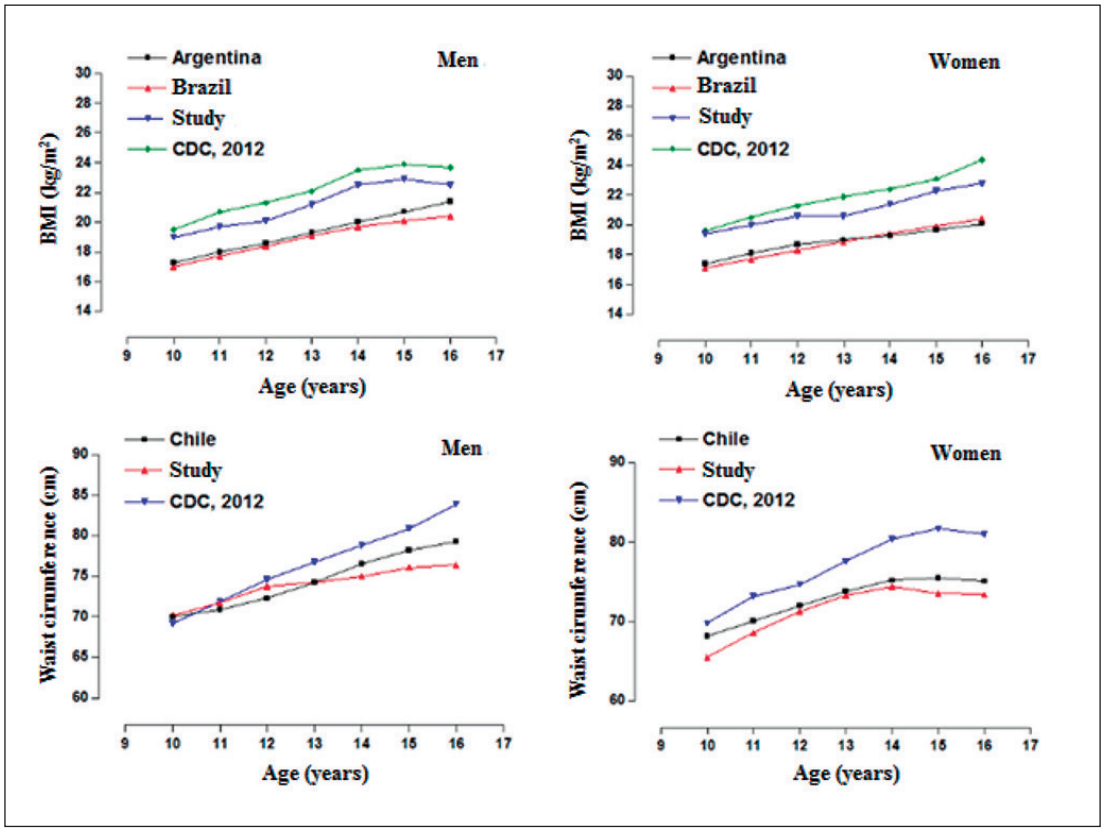

Figure 1. Comparison of body adiposity indicators with international studies (p50).

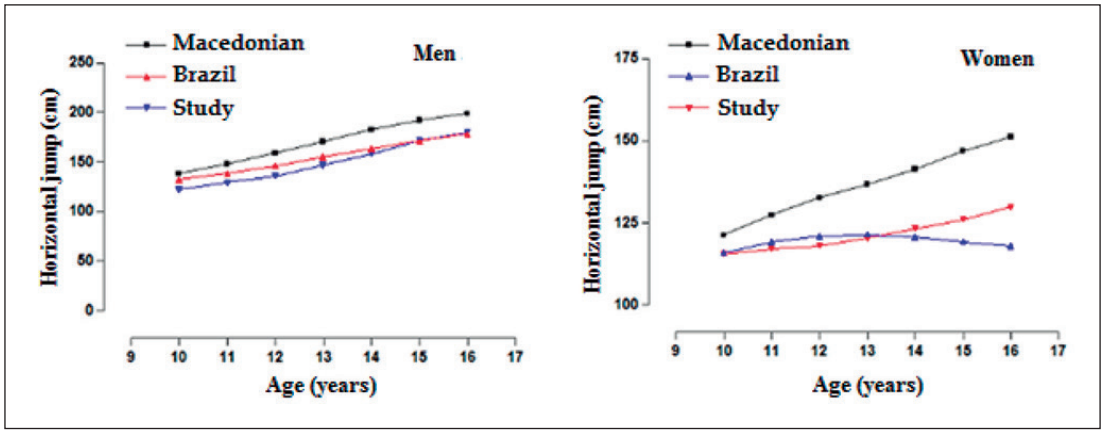

Figure 2. Comparison of the horizontal jump with international studies.

observed only when classified by WC, while by BMI, despite evidencing slightly elevated values, there were no significant differences ($p > 0.05$) (table 2).

Figure 2 shows the relationships between body fat indicators and HJ performance. Negative and significant correlations between BMI and HJ (men r = -0.104 and women r = -0.149) and between WC and HJ (men r = -0.100 and women r = -0.131) were verified in both sexes (figure 3).

Discussion

The first objective of this study was to compare body fat and horizontal jump performance with international studies. The results indicate that the studied schoolchildren showed BMI values relatively lower than the American CDC-2012[13] reference, and higher than the studies carried out in Argentina[15] and Brazil[14]. Concerning WC, the percentile values (p50) are lower

Table 2. Mean values and ± SD of the indicators of corporal adiposity and horizontal jump by categories (terciles)

Variables	Men						Women					
	Tercile 1 (Good)		Tercile 2 (Satisfactory)		Tercile 3 (Poor)		Tercile 1 (Good)		Tercile 2 (Satisfactory)		Tercile 3 (Poor)	
	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
Terciles by BMI												
BMI (kg/m²)	17.6	1.3	20.9	0.9[a]	26.1	3.1[ab]	17.5	1.4	20.7	1.0[*]	25.9	3.1[*,**]
WC (cm)	66.8	6.6	73.7	6.6[a]	83.1	11.3[ab]	64.4	6.0	69.6	6.7[*]	79.9	8.3[*,**]
HJ (cm)	149.4	28.2	145.4	34.0	142.0	32.8[a]	122.8	18.7	120.7	22.5	118.5	16.4
Terciles by WC												
BMI (kg/m²)	18.9	2.8	21.0	3.0[a]	24.9	3.8[ab]	18.4	2.1	20.7	2.4[*]	25.2	4.0[*,**]
WC (cm)	63.9	4.8	73.6	2.5[a]	87.1	7.5[ab]	61.8	3.4	70.4	2.5[*]	82.5	6.5[*,**]
HJ (cm)	146.2	28.1	150.8	36.2	139.4	29.5[b]	119.9	20.0	124.1	18.6	117.8	19.1[**]

BMI: Body Mass Index, WC: Waist circumference, HJ: Horizontal jump, (in men, a: significant difference in relation to tercile 1, b: significant difference in relation to tercile 2), (in women, *significant difference in relation to tercile 1, **significant difference in relation to tercile 2).

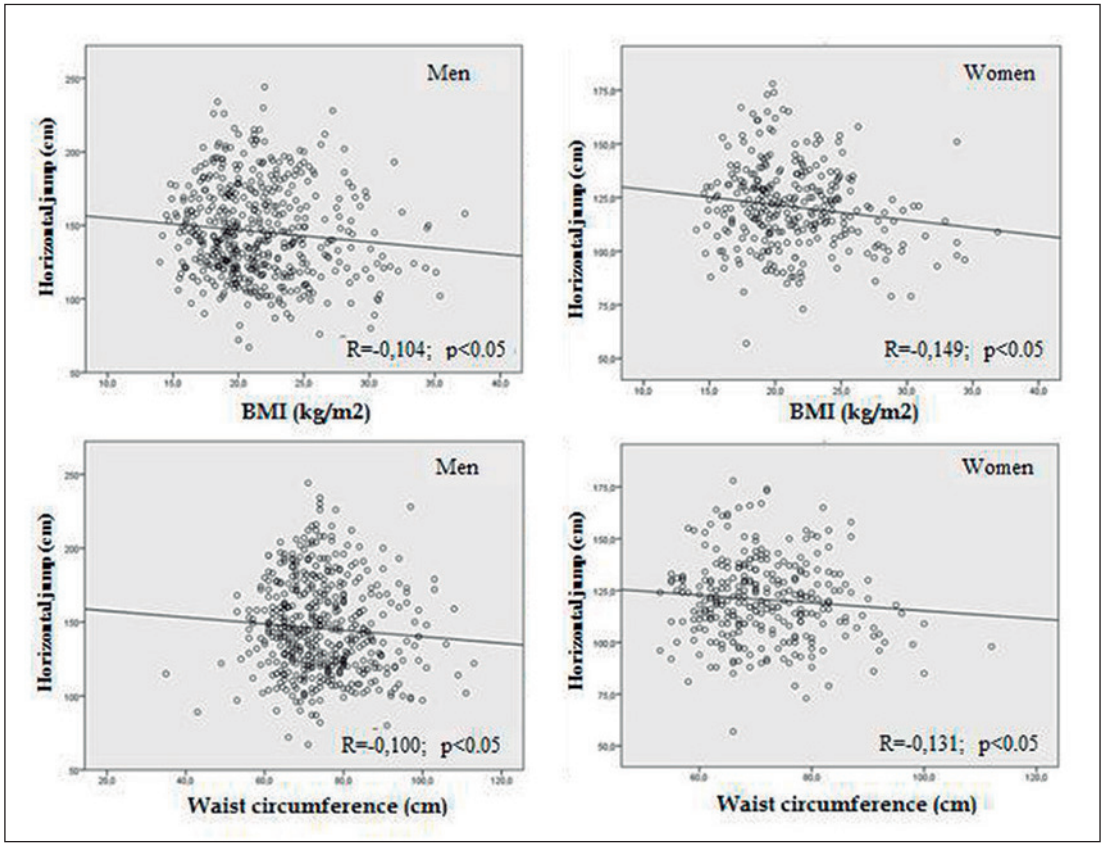

Figure 3. Relationship between body adiposity indicators with the horizontal jump of adolescents of both sexes.

than those of CDC-2012[13] reference and relatively similar to the regional study of Chile[16]. These findings confirm that body fat patterns expressed in BMI and WC are normal since they evidenced similar behavior with national and international studies[20-22], especially between the ages of 10 and 16 and in both sexes.

With respect to the values of the percentile p50 of the horizontal jump, the findings indicate that the boys and adolescent men of the El Maule Region reflect a similar pattern with the international studies, in which a clear linear increase of HJ is observed as the age increases, whereas in women this tendency is

similar but less pronounced. Evidently, this reflects a less accentuated increase compared to men, which makes them a focus of attention on the part of local, regional, and national government to develop intervention groups.

In that sense, these results provide valuable information about adolescents, since during the process of growth and development[23] intense biological, psychological and cognitive changes take place, which must be considered mainly in women. This means placing emphasis on increasing physical activity to improve levels of physical performance and to reduce and/or maintain healthy body composition[24]. In fact, several studies have shown that muscle power and overall muscle strength correlate negatively with obesity in children[5] and positively in adults with functional status and bone health, respectively[25].

In this context, in an era where overweight and obesity are gradually increasing worldwide[26], it is necessary to pay attention to the studied adolescents in order to maintain their level of body fat and improve the performance of HJ since it is widely known that adipose tissue negatively influences physical-sports activities that require agility, speed, stamina, movement and jumping, consequently a high level of physical fitness in childhood and/or adolescence is associated with more favorable health outcomes such as the risk of future obesity, cardiorespiratory diseases, deterioration of skeletal and mental health[4]. Therefore, showing acceptable levels of BMI, WC and HJ for their age and sex appears to be relevant to maintaining good health at the population level.

Consequently, after comparisons between terciles and classified by BMI and by WC, the results indicate that men reflect differences in HJ when classified by BMI and in women when classified by WC. The results reflected negative correlations between adiposity indicators with HJ in both sexes. These findings indicate that body fat negatively impairs HJ performance, despite the fact that the studied schoolchildren have apparently normal adiposity patterns.

In fact, previous studies have indicated that body size and weight are negatively correlated with motor tests, where the body is projected as the center of gravity specifically in HJ[23], although there are other studies that have shown positive correlations[28] after analyzing subjects in populations without body weight excess, because evidently, fat-free mass plays a relevant role in muscle aptitude tests specifically in populations of physically active schoolchildren.

In general, body fat or excess adiposity negatively affects health and physical performance related to physical fitness[30], especially in populations where there is minimal presence of body weight excess and mainly higher prevalence of low weight and height. Although stronger negative correlations between BMI-WC and HJ could be considered as more sedentary populations, as well as positive correlations could be extrapolated to samples that reflect normal or low weight, probably due to the presence of greater muscle mass and even more physically active groups.

The study presents some potentialities, for example, the selection of the sample applied to the research is probabilistic, in addition to being the first research conducted in the El Maule Region and Chile with these characteristics, and therefore it could be generalized to other contexts with similar characteristics and could be useful as a baseline for future comparisons. However, it is also necessary to recognize some limitations, given the impossibility of assessing variables such as eating habits, the time they dedicate to physical-sports activities inside and outside schools, and biological maturation. Future research needs to consider these aspects in its research designs, although sexual maturation is still an invasive technique that is dependent on the individual's subjectivity and cultural factors for proper use.

In conclusion, there was more body fat and less performance in HJ compared to international studies. In addition, a negative relationship between body fat and HJ was verified. These findings suggest that the progressive increase in adiposity as chronological age increases negatively limits the strength performance of the lower extremities of the studied adolescents, mainly in women. These findings should be useful to reflect on the real state of the morphofunctional dimension of the studied adolescents, although in order to verify these results, it is necessary to develop more studies. The results suggest an urgent intervention, especially in women, to improve muscle performance and body fat levels.

Ethical responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Financial Disclosure

Authors state that no economic support has been associated with the present study.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

References

1. Ahima RS. Adipose tissue as an endocrine organ. Obesity (Silver Spring). 2006;14(suppl 5):242S-9S. doi: 10.1038/oby.2006.317
2. Seidell JC, Hautvast JG, Deurenberg P. Overweight: Fat distribution and health risks. Epidemiological observations. A review. Infus. Basel Switz. 1989; 16: 276-281. doi: 10.1159/000222401
3. Bennasar-Veny M, Lopez-Gonzalez A, Tauler P, Cespedes L, Vicente-Herrero T, Yañez A, Tomas-Salva M, Aguilo A. Body Adiposity Index and Cardiovascular Health Risk Factors in Caucasians: A Comparison with the Body Mass Index and Others. PLoS ONE. 2013;8(5):e63999. doi:10.1371/journal.pone.0063999.
4. Ortega FB, Ruiz JR, Castillo MJ, Sjöström M. Physical fi tness in childhood and adolescence: a powerful marker of health. Int J Obes (Lond). 2008;32:1-11.
5. Ruiz JR, Castro-Piñero J, Artero EG, Ortega FB, Sjöström M, Suni J, Castillo MJ. Predictive validity of health related fitness in youth: a systematic review. Br J Sports Med. 2009; 43:909-23.
6. Gatica-Mandiola P, Vargas-Vitoria R, Amaro J, et al. Cambios en la adiposidad corporal de adolescentes escolares (1997-2007). Nutr Clín Diet Hosp 2013;33(3):23-9.
7. Cossio-Bolaños M, Vilchez-Avaca C, Contreras-Mellado V, Andruske C, Gómez-Campos R. Changes in abdominal obesity in Chilean university students stratified by body mass Index. BMC Public Health. 2016;16:33.
8. Artero EG, España-Romero V, Castro-Piñero J, et al. Criterion-related validity of field-based muscular fitness tests in youth. J Sports Med Phys Fitness. 2012; 52(3):263-72.
9. Pate R, Oria M, Pillsbury L. (Eds.). Fitness measures and health outcomes in youth. Washington, DC: National Academies Press, 2012.
10. Golle K, Muehlbauer T, Wick D, Granacher U. Physical fitness percentiles of German children aged 912 years: findings from a longitudinal study. PLoS One. 2015;10(11):e0142393 DOI 10.1371/journal.pone.0142393.
11. International Society For the Advancement of Kinanthropometry (ISAK). International Standards For Anthropometic Assessment. Nueva Zelanda. 2001.
12. Castro-Piñero J, Ortega FB, Artero EG, et al. Assessing muscular strength in youth: usefulness of standing long jump as a general index of muscular fitness. J Strength Cond Res. 2010; 24: 1810-7.
13. Fryar CD, Gu Q, Ogden CL. Anthropometric reference data for children and adults: United States, 2007-2010. National Center for Health Statistics. Vital Health Stat 2012;11(252).
14. Gómez-Campos R, Arruda M, Hespanhol JE, Camargo C, Briton RM, Cossio-Bolanõs MA. Referencial values for the physical growth of school children and adolescents in Campinas, Brazil. Annals of Human Biology. 2014;42(1):1-8.
15. Alfaro E, Bejarano I, Dipierri J, Quispe Y, Cabrera C. Percentilos de peso, talla e índice de masa corporal de escolares jujeños calculados por el método LMS. Arch Argent Pediatr. 2004;102(6):431-9.
16. Gómez-Campos R, Andruske C, Hespanhol JE, et al. Waist Circumferences of Chilean Students: Comparison of the CDC-2012 Standard and Proposed Percentile Curves. Int. J. Environ. Res. Public Health. 2015; 12: 7712-24.
17. Hobold H, Pires-Lopes V, Gómez-Campos R, et al. Reference standards to assess physical fitness of children and adolescents of Brazil: an approach to the students of the Lake Itaipú region Brazil. PeerJ. 2017;5:e4032; DOI 10.7717/peerj.4032.
18. Gontarev S, Zivkovic V, Velickovska LA, Naumovski M. First normative reference of standing long jump indicates gender difference in lower muscular strength of Macedonian school children. Health. 2014;6(1):99-106.
19. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. BMJ. 2000;320:1240-43.
20. Fernández JR, Redden DT, Pietrobelli A, Allison DB. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. J. Pediatr. 2004; 145:439-44.
21. Vargas ME, Souki A, Ruiz G, et al. Percentiles de circunferencia de cintura en niños y adolescentes del municipio Maracaibo del Estado Zulia, Venezuela. An. Venez. Nutr. 2011;24:13-20.
22. Chaves R, Baxter-Jones A, Souza M, Santos D, Maia J. Height, weight, body composition, and waist circumference references for 7- to 17-year-old children from rural Portugal. HOMO - Journal of Comparative Human Biology. 2015; 66:264-77.
23. Milanese Ch, Bortolami O, Bertucco M, Verlato G, Zancanaro C. Anthropometry and motor fitness in children aged 6-12 years. J. Hum Sport Exerc. 2010;5(2): 265-79.
24. Haugen T, Høigaard R, Seiler S. Normative data of BMI and physical fitness in a Norwegian sample of early adolescents. Scandinavian Journal of Public Health. 2014;42:67-73.
25. Reid KF, Fielding RA. Skeletal muscle power: A critical determinant of physical functioning in older adults. Exercise and Sport Science Reviews. 2012;40: 4-12.
26. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults. 1999-2000. JAMA. 2002;288(14):1723-7.
27. Butcher JE, Eaton WO. Gross and fine motor proficiency in preschoolers: relationships with free play behaviour and activity level. Journal of Human movement studies. 1989;16:27-36.
28. Monyeki MA, Koppes LL, Kemper HC, et al. Body composition and physical fitness of undernourished South African rural primary school children. Eur J Clin Nutr. 2005;59(7):877-83.
29. Tokmakidis SP, Kasambalis A, Christodoulos AD. Fitness levels of Greek primary schoolchildren in relationship to overweight and obesity. Eur J Pediatr. 2006;165(12):867-74.
30. Pate RR, Slentz CA, Katz DP. Relationships between skinfold thickness and performance of health related fitness test items. Res Q Exerc Sport. 1989;60(2):183-9.
31. Malina RM, Beunen GP, Claessens AL, et al. Fatness and physical fitness of girls 7-17 years. Obesity Research. 1995; 3:221-31.