Original Article

Physical activity and physical fitness in children and their relationship on body fat

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ABSTRACT

Low levels of physical activity and physical fitness are risk factors of obesity and cardiovascular disease from childhood to adulthood. According to several studies, inactivity increases with the age of the school students. In Spain, according to results of the 2018 Report, only 34% of boys and 27% of girls aged 3 to 14 are active. This study aimed to compare differences between genders in body composition and PA; to analyse the relationship between the variables studied. Methods: This study used a non-experimental research design. PAQ-C questionnaire and ALPHA-Fitness tests were used. Descriptive analysis, correlation and linear regression gave the following results: boys had better scores in PA, and worse in BF percentage. PA in boys is related to aerobic capacity (r = 0.426, $p < .01$), BMI and BF (r = -0.368, and -0.323, $p < .01$ respectively). BF variability in boys ($R^2 = 0.35$) is determined by aerobic capacity (t = -4.161; $p < .01$) and lower-body explosive strength (t = -3.832; $p < .01$). Findings show an association between PA and the elements of PF studied, and an explanatory model of body fat based on aerobic capacity and lower-body explosive strength in boys.

Keywords: Physical education; Primary school; Aerobic capacity; Explosive strength; PAQ-C.

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INTRODUCTION

Various national and international institutions and bodies are now concerned about physical activity (PA) and, therefore it is important to improve physical fitness (PF) in the general population, specifically in children, as a means of improving health and preventing diseases and pathologies that are largely associated with inactivity and a sedentary lifestyle (Cureton et al., 2013; Ortega et al., 2008; Ruiz et al., 2011).

The World Health Organization (WHO) (Bull et al., 2020) and Spanish Ministry of Health, Social Services and Equality (Aragonés et al., 2015) recommend at least 60 minutes per day of moderate to vigorous physical activity for maintaining an active lifestyle from a young age. Guidelines that give priority to cardiorespiratory capacity and muscle strength exercises as these two elements are considered significant health markers in children and teenagers (Ortega et al., 2008).

School is considered an ideal setting for children's PA promotion (Murillo et al., 2013; Cepero et al., 2011), where areas such as physical education, school recess and active school commuting can provide multiple opportunities to meet PA recommendations. However, current research trends highlight a lack of PA based on these recommendations; with significant differences by gender around the world (Kalman et al., 2015).

According to several studies, inactivity increases with the age of the school students, fundamentally from secondary education onward (Lee et al., 2015; Román-Viñas et al., 2018; Arriscado et al., 2017). In Spain, according to the results of the 2018 Report (Fundación para la investigación Nutricional, 2018), only 34% of boys and 27% of girls aged 3 to 14 are active. This PA can predict morbidity and mortality due to cardiovascular disease and is a decisive factor for longevity and quality of life related to health at all ages (Ruiz et al., 2011; Casas et al., 2014).

During the pandemic, effects of inactivity are even more evident due to forced reduction in mobility. According to recent studies (Arévalo et al., 2020; Rundle et al., 2020; Zhu et al., 2021) worsening PF and increasing body fat (BF) are subsequently increasing cardiovascular and metabolic risk.

PF values in children from a health perspective include cardiorespiratory capacity, strength, muscle resistance, flexibility, body composition, speed, and agility. By gender, several studies showed how boys had significantly higher PF levels than girls, especially in the parameters of muscle resistance and strength (He et al., 2011; Wang et al., 2011). PF also falls with age, more sharply among females, as a result of progressive reduction in PA (Zhu et al., 2021; Martínez-Martínez et al., 2018; Chacón-Borrego et al., 2020).

According to research studies detailed below, PA and PF help prevent excess weight and obesity, and also improve aerobic capacity (AC), in children and adults (Goldfield et al., 2012; López-Sánchez et al., 2016). This paper aims to respond to the following questions: What is the relationship between PA and PF in school children aged 10-12?; Is there a predictive effect between both variables and specifically on BF?

The relationship between PA and health variables from a physical perspective has been studied in different age groups, especially in teenagers. In the scientific literature, the interplay between PA and AC with cardiometabolic health is less clear. Several studies showed a positive association between physical exercise and AC, strength, flexibility and body composition.

Studies with children under 13 also show that more active subjects have better PF than those who are inactive (Arriscado et al., 2017). By gender, fundamentally moderate and vigorous intensity PA (MVPA) has a negative association with BF (Ortega et al., 2013), especially in males (Basterfield et al., 2012; Jiménez-Pavón et al., 2010), protecting against increased weight and fat accumulation (Abril et al., 2013) which also improves AC and VO_{2max} (Arriscado et al., 2017; Brouwer et al., 2013).

Regarding BF, children with better PF are exposed to lower risk of excess BF and improved AC, therefore, to lower cardiovascular risk during adulthood (Brouwer et al., 2013; Castro-Piñeiro et al., 2009; Casajús et al., 2012). Even school children with excess weight and obesity but good BF values have a lower cardiovascular risk than those with low PF (Ortega et al., 2013). Specifically, healthy AC values reduce BF percentage (Rush et al., 2014). This AC, expressed as maximum oxygen consumption (VO_{2max}) —over 42 mL/kg/min for boys and 35-37 mL/kg/min for girls (Castro-Piñero et al., 2017) —, is associated with lower risk of excess weight and obesity, and also with lower metabolic risk (Ortega et al., 2013).

Suitable AC levels during childhood and adolescence are also associated with a healthy cardiovascular profile during adulthood (Kodama et al., 2009) and better results in other PF parameters such as muscle strength (Guillamón et al., 2015). In fact, Ruiz et al. (2011) found how better muscle strength values are also associated with healthier BF values.

Moreover, an unhealthy weight, measured using body mass index (BMI) and BF values, is associated with poorer performance in lower-body explosive strength (LBES), AC and VO_{2max} tests (Castro-Piñeiro et al., 2011; Rosa-Guillademón et al., 2015).

However, few studies have analysed the relationships between BF with AC, strength, muscle resistance, flexibility, body max index (BMI) and/or speed (Liew et al., 2011; Dencker et al., 2011) by gender around the world. In United States, Liew et al. (2011) found that no significant gender differences were found on BMI and PF except for boys out-performing girls on physical fitness in primary grade 5. In contrast, in Spain, a study showed how in girls, BMI acts as a full mediator in the relationship between AC and cardiometabolic risk factor in schoolchildren (Díez-Fernández, 2014). Finally, several researchers from Sweden found significant relationships between BF measurements and AC in both boys and girls (Dencker et al., 2011). The interplay between these variables in relation to the cardiometabolic risk profile is unclear.

Reviewing existing research on the scope of this study during primary education highlights a lack of studies analysing the cause-effect relationship between PA and PF by gender, also stressed by Guillamón et al. (2015). Therefore, the objectives set in the study were: to compare differences between genders in body composition and PA; to analyse the relationship between the variables studied.

MATERIAL AND METHODS

Study design and Participants

The design of this study is descriptive, correlational, explanatory, cross-sectional and non-experimental (Hernández et al., 2014).

Contact and access to certain schools meant that the sample, selected by non-probabilistic incidental sampling, comprised 146 subjects: 50.7% girls and 49.3% boys, aged from 10 to 12. Year 5 and 6 primary pupils of 3 public educational centres in the city of Seville (Spain). Exclusion criteria: children with cardiorespiratory, musculoskeletal or any other pathologies that prevent the practice of physical-sporting activity.

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Biomedical Research Ethics Committee of Andalusia (Code 0305-N-19).

Measures

The PAQ-C Physical Activity Questionnaire was used to analyse PA level in children (Manchola-González, 2017). Applied to children aged 8 to 14, it assesses PA in the last seven days and classifies them as active or inactive according to activity levels.

The questionnaire comprises ten items, nine ordinal variables on PA, with a Likert scale of 1-5, and a last item to assess whether any illness could prevent PA in the last week. For example, item 2. "*During physical education classes, how many times were you active during class: intense playing, running, jumping, throwing?*" (1 = "*I did not do PE*", 2 = "*Almost never*", 3 = "*Sometimes*", 4 = "*Often*", 5 = "*Always*"); item 3. "*In the last seven days, what did you do at break time?*" (1 = "*Sit down*", 2 = "*Stand or walk around*", 3 = "*Run or play a little*", 4 = "*Run or play a lot*", 5 = "*Run and play intensely all the time*"). The general result of the questionnaire is a score from 1 to 5 obtained as a mean of scores from the first nine items. Assessing PA results shows Low physical activity (score = 1), Moderate (score = 2–4), and Vigorous (score = 5) that indicates a higher level of activity (Kowalski et al., 2004). In the study, this instrument has good internal consistency (α = 0.86), similar to the figure obtained validating the questionnaire (α = 0.83).

The PF variables included in this study are part of the ALPHA-Fitness Battery (Ortega et al., 2013) described below:

1. Body composition: height with Holtain stadiometer (Holtain Ltd., Dyfed, United Kingdom) with a precision of 1 mm, recorded in cm. Weight, BMI and BF percentage measured with OMRON BF511 electronic bioimpedance scales. BMI was measured according to the formula: BMI = weight (kg)/ height (m2).
1. To estimate body fat, the standard error of estimate (SEE) of the device is 3.5% (instruction manual, OMRON BF511, technical data). Measurements were taken according to the manufacturer's guidelines.
2. Skeletal muscle capacity: standing broad jump test to determine lower-body ex-plosive strength, consisting in jumping forward with both feet together from standing. Two jumps; the best score was recorded. A PVC and fiberglass measuring tape was used for this test (Model 74-Y100M, CST/Berger, Chicago, USA).
3. Aerobic capacity: 20 m shuttle run test. This test consists of running from one line to another 20 meters away, adapting the run to the pace set by an acoustic signal. Speed increases by 0.5 km/h each minute from an initial speed of 8.5 km/h; each 1-minute period is considered a stage. The test ends when the pupil fails to reach the 20 m line by the time the signal sounds twice consecutively. The result recorded is the number of stages completed. Portable audio equipment and a USB stick with the audio recording were used for this test.

Procedures

Prior to data collection, a meeting was held with school management teams to inform them about the project and request their authorization. Teachers, families and children were then informed about the tests and the period during which they would take place. An informative letter was distributed along with an informed consent form for families; children wanting to participate in the study had to return the informed consent form signed by their parent or legal guardian as the study involves minors.

After this process, we collected data using the PAQ-C questionnaire. Moreover, we conducted the ALPHA-Fitness tests according to the sequence recommended in the instruction manual (Ortega et al., 2013). The previous battery was assessed during two physical education classes.

Analysis
Firstly, for objective 1, descriptive bivariate analyses were conducted using different tests depending on the nature of the variables detailed below.

New ordinal and nominal variables were created from quantitative variables, which were analysed with Pearson's Chi-Squared test to determine gender differences:

- "*BMI Level*" and "*BF Level*", created from quantitative variables ("*BMI*" and "*BF*") according to WHO criteria (World Health Organization, 2006), was analysed to assess obesity based on BMI < 18.5 under-weight; ≥ 18.5 and < 25 normal weight; ≥ 25 and < 30 overweight, and ≥ 30 obesity, and according to McCarthy et al. (2006), to interpret BF percentage according to sex and age. Four groups of pupils were created based on whether values were low (value 0), normal (value 1), high (value 2) or very high (value 3).
- "*Activity level*", transformation of the quantitative "*PA*" variable (sum of variables 1-9 on the PAQ-C questionnaire) into a nominal variable differentiating active pupils (coded with value 0) from inactive pupils (value 1) according to the cut-off point established by Benítez-Porres et al. (2016). According to results obtained in the Kolmogorov-Smirnov normality test, mean value of PA was compared according to the U Mann-Whitney test.

Secondly, regarding study objective 2, Spearman's rank coefficient correlation was used for analysis. And a multiple linear regression analysis using the stepwise method, selecting the variable "*sex*" was used to identify BF variability according to PA, LBES and AC covariates.

To know the effect size and statistical power of the results obtained, specific post hoc tests were applied for each type of analysis. The Cohen's criteria of small, medium, and large effects were used: W = 0.10, 0.30, 0.50; r = 0.01, 0.30, 0.50 y $f2$ = 0.02, 0.15, 0.35. The statistical power values were from 0.80 (Cohen, 1988).

Data were analysed with IBM SPSS version 26.0 (IBM Corp., Armonk, NY, USA) software for Windows.

RESULTS

The characteristics of the study participants are presented in Table 1.

Table 1. Characteristics of the subjects participating in the study.

	n = 146			Girls (n =74)	Boys (n =72)
	Min.	Max.	Mean (SD)	Mean (SD)	Mean (SD)
Age	10	12	10.92 (0.71)	10.85 (0.69)	10.96 (0.74)
Weight	26.9	75.7	44.46 (10.03)	43.20 (10.17)	45.75 (9.79)
Height	131	175	149.13 (7.74)	148.28 (8.40)	149.99 (6.95)
BMI	13.6	31.3	19.79 (3.2)	19.44 (3.34)	20.16 (3.03)
BF	8.6	40.3	23.72 (7.08)	23.77 (7.34)	23.67 (6.86)

Note. Variables are expressed as mean value and SD (standard deviation). BMI: body mass index; BF: body fat percentage.

As the following Table 2. shows, there were no significant gender differences based on healthy and unhealthy BMI values. Around 95% of girls and boys had a under or normal weight. The over-weight and obesity values were also very similar between boys and girls, 5.5% and 6.9% respectively.

However, there were differences in the levels of healthy and unhealthy BF as shown in Table 2.; boys had higher values of overweight and obesity levels than girls (33.3% of boys compared to 14.9% of girls). The Chi-squared test showed that gender differences in BF had a close to medium effect size (W = 0.254), and statistical power was slightly below 0.8. The contingency coefficient had a value of 0.227.

Table 2. Children with healthy or unhealthy Body Mass Index (BMI) and Body Fat (BF).

		Under and normal weight	Overweight	Obesity	Total	χ^2	*p*
BMI Level	Girls	94.5	4.1	1.4	100	6.561	*.087*
	Boys	93.1	6.9	0	100		
BF Level	Girls	75.1	9.5	5.4	100	7.922	*.0481*[1]
	Boys	66.6	25.0	8.3	100		

Note. Values expressed in %. Distribution based on BMI and BF values by gender and age. [1]Effect size, Chi-Squared = 7.922 (3), Sig. = .048, 1-β = 0.73 W= 0.254.

Descriptive PA throughout the week indicated that boys obtained better results than girls (M = 3.21 and M = 2.83). The Mann-Whitney U test between PA and gender showed a Z (137.41) = 4.1180, sig. = 0.001; effect size large, very close to 0.8 (d = 0.74), and statistical power values of 1-β = 0.96. According to the mean PA obtained in the PAQ-C, the percentage of active boys was 72.2% and of active girls was 54.1%.

Results obtained in the correlation analysis (Table 3.) showed that in girls PA does not have any correlation with variables of body composition or PF. BMI and BF are negatively correlated with AC and VO_{2max}. AC is positively related to LBES.

Table 3. Correlation analysis between PA, PF and body composition variables.

			PA	BMI	BF	LBES	AC	VO_{2max}
Girls	PA	r	1	-0.009	-0.023	0.043	0.071	-0.002
	BMI	r		1	*0.910***	-0.067	*-0.274**	*-0.771***
	BF	r			1	-0.142	*-0.283**	*-0.620***
	LBES	r				1	*0.249**	0.131
	AC	r					1	0.203
Boys	PA	r	1	*-0.368***	*-0.323***	*0.273**	*0.426***	-0.123
	BMI	r		1	*0.905***	*-0.466***	*-0.570***	*0.574***
	BF	r			1	*-0.521***	*-0.582***	*0.370***
	LBES	r				1	*0.369***	-0.187
	AC	r					1	0.185

*Note. r: Spearman's correlation coefficient. *Significant correlation in level .05 (bilateral). **Significant correlation in level .01 (bilateral).*

In boys, PA relates positively with LBES, AC and VO_{2max} variables, and negatively with BF, and BMI. BMI and BF variables had a negative correlation of moderate intensity with LBES and AC. Significant results obtained in the correlation analysis in both girls and boys showed a large effect size with values between .49 and .95, and a statistical power over .80.

A multiple linear regression model was created with BF percentage as the dependent variable and covariates: PA, AC, LBES.

Results obtained using stepwise regression find the best predictive model for variability of BF in boys ($F = 14.68$, $p < .01$) with a Multiple Regression R^2 value of 0.375. The values obtained in the Durbin-Watson (2.090) and VIF (1.055) statistics are considered valid for this type of analysis (Yin, 2020).

Variables included in the equation are AC ($t = -4.161$; $p < .01$) and LBES ($t = -3.832$; $p < .01$). BF = 45.94 - 1.040 (AC) – 0.126 (LBES).

The results in Table 4. showed that all the indices of significance, statistical power and effect size are adequate to predict the variability of 37.5% of body fat. No BF regression model was found in girls.

Table 4. Regression model for the dependent variable "Body Fat" in boys. Effect size values.

	F	**R2**	**ΔR2**	**B**	**Std. error**	**β**	***p***	**1-β**	***f*²**
MODEL	20.717 (2.69)	0.375	0.357				.001	0.994	0.587
AC				-1.040	0.250	-0.407	.001		
LBES				-0.126	0.033	-0.375	.001		

Note. Variables AC: Aerobic capacity, and LBES: lower-body explosive strength.

DISCUSSION

Considering results related to the first objective "*to compare differences between genders in body composition variables, and PA*": results for anthropometric variables in the PF health model, school children from the south of Spain (Seville) showed BMI values with little difference between sexes (M = 19.4 in girls and M = 20.16 in boys). Similar data were obtained for children in Spain in studies including school pupils aged 11-12 from the north of Spain (Logroño) (Arriscado et al., 2017) and children aged 8-12 from the southeast, Murcia (GuilLademón et al., 2015); nevertheless, figures are lower than those obtained from schools in central Spain, Toledo (Martínez-Martínez et al., 2018). The prevalence of overweight and obesity is influenced by different factors. Variations are observed in the prevalence of excess weight according to geographic distribution, social level, ethnic group and educational centres (Amigo et al., 2007). In all studies, including this paper, most pupils in this age range have normal weight. However, comparing children with excess weight and obesity based on BMI, lower excess weight and obesity values were found —6.9% in girls and 5.5% in boys— compared to other studies in children aged 10 to 14 by the National Health Survey (28.1% and 23.8% respectively) (Aragonés et al., 2015) or the study on children aged 8 to 11 in the Region of Murcia in which girls with excess weight and obesity accounted for 51.3% of the sample and boys 48.7% (Rosa-Guillademón et al., 2015). According to the Spanish National Health Survey, in Spain there is a higher prevalence of obesity in boys than in girls. The fact that the opposite occurs in the present study may be related to the type of students studied, that it included students who belong to families of low socioeconomic status. In line with this, the scientific literature has observed a higher dietary intake, especially in more disadvantaged groups, who, when increasing their income without adequate nutritional education, would choose to buy foods with high energy density, which would contribute to the weight gain (Flood et al., 2006).

Difference between genders in PA in girls and boys throughout the week (2.83 in girls and 3.22 in boys) was similar to other studies using the PAQ-C questionnaire to determine PA levels, such as Lee et al. (Lee et al., 2015) (M = 2.41 and M = 2.62, respectively) and Arriscado et al. (2015) in children from the north of Spain aged 11-12 where girls have a score of 2.08 and boys 3.2. However, percentages of active school pupils are higher (54.1 girls and 72.2 boys), and also higher than those obtained in research studies including the 10-12 age group such as the Health Study of Catalonia on children aged 3 to 14 (Generalitat de Catalunya, 2016) —26.9% girls and 34.2% boys—, or the ANIBES Study (Ruiz et al., 2015) in children aged 9 to 12 in which 38% and 61% are active, respectively. These differences may be justified by the use of different instruments to measure PA: PAQ-C questionnaire (Arriscado et al., 2015), accelerometry (Ruiz et al., 2015) or non-validated questionnaires (Generalitat de Catalunya, 2016).

Regarding the second objective of this study "*to analyse the relationship between the variables studied*", correlation analysis indicated that higher PA values are associated with better PF results in AC, VO_{2max} and LBES parameters. This PA-PF relationship has been verified in prior research in both Spain (Flood et al., 2006) and the Asian population in other countries (He et al., 2011). A negative PA-BF percentage association was obtained, as in research using objective methods to determine PA (Ekelund et al., 2004; Chaput et al., 2012). However, when comparing with other studies using PAQ-C as a qualitative method to determine PA, results are not unanimous. Some do report an association between both variables such as research conducted among Asian children aged 7-12; similar findings were obtained in this study between PA and BMI (Lee et al., 2015) and others, such as Arriscado et al. (2015) in children from the north of Spain, found no relationship between PA and BF. Different body composition and physical-health condition parameters are correlated: BMI has a negative relationship with LBES, AC and VO_{2max} variables, and the negative relationship between BF percentage and LBES and AC is greater, which coincides with results among children in the Region of Murcia (Guillamón et al., 2015). AC is also a determining factor in LBES and BF so that higher values in this capacity and in VO_{2max} are related to higher strength and BF values, matching studies such as Helena (Moliner-Urdiales et al., 2011), AVENA (Ortega et al., 2013), and in 298 children aged 8-12 in the Region of Murcia (Guillamón et al., 2015).

Regression analysis results showed that BF variability in boys is essentially determined by AC values and, to a lesser extent, by LBES. This influence was not found in girls, so perhaps, other variables could influence this result. We think that it could be due to the existence of genetic predisposition and other environmental and biological factors (e.g., the existence of differences in the food between boys and girls), which could influence the interplay among the previous variables. PA cannot be used to predict BF in this study unlike a study on 1,292 children aged 9-10 in four regions of Europe (Ekelund et al., 2004), which did find a relationship —albeit weak— between MVPA and BF, and also a study among 1,971 subjects aged 7-12 in Malaysia, in which the PA obtained objectively and subjectively caused variations in BF of 2.4% (Lee et al., 2015). An analysis of prior research confirms the lack of explanatory studies in recent years on the 10-12 age range. Knowledge on the impact some parameters have on others could therefore be improved, as well as experimental or quasi-experimental research such as the study on obese teenager school pupils that verified, after eight months of intervention with activities of different intensities, that only high-intensity activities improve AC and that MVPA affects adiposity (Gutin et al., 2002).

CONCLUSIONS

Boys have higher levels of unhealthy BF than girls. Greater PA in boys is related to better AC, LBES and BF values and, on the contrary, higher BF and BMI in both genders are associated with poorer AC, VO_{2max}. In boys higher BF is also related to lower LBES values. BF variability in boys can be explained by changes in

AC and LBES. No explanatory model was found for body fat in girls. Future studies should: aim to expand research on the variables analysed during primary and preschool education; include other variables such as diet; and multivariant studies should be conducted in order to establish explanatory models related to PF and PA.

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No potential conflict of interest was reported by the author.

REFERENCES

Abril, V., Manuel-Y-Keenoy, B., Solà, R., García, J.L., Nessier, C., Rojas, R., Donoso, S., & Arija, V. (2013). Prevalence of overweight and obesity among 6- to 9-year-old schoolchildren in Cuenca, Ecuador: Relationship with physical activity, poverty, and eating habits. Food Nutr Bull., 34(4), 388-401. https://doi.org/10.1177/156482651303400404

Amigo, H., Bustos, P., Erazo, M., Cumsille, P., & Silva, C. (2007). Determinant factors of excess of weight in school children: a multi-level study. Rev. Méd. Chile, 135(12), 1510-1518. https://doi.org/10.4067/S0034-98872007001200002

Aragonés, E.A., Merino, B.M., Esteban, P.C., Luciano, A.G., Santacilia, I.Z., Claramonte, M.T., Santaolaya, M., & Justo, S. (2015). Recomendaciones actividad física Estrategia Promoción Salud y Prevención. Estrategia de promoción la salud y prevención en el SNS. Ministerio de Sanidad, Servicios Sociales e Igualdad.

Arévalo, H., Triana, M.U., & Santacruz, J.C. (2020). Impact of mandatory preventive isolation on daily physical activity and weight of children during the SARS-cov-2 pandemic. Rev Colomb Cardiol., 27(6), 589-596. https://doi.org/10.1016/j.rccar.2020.09.003

Arriscado, D., Dalmau, J.M., Zabala, M., & Muros, J.J. (2017). Health-related physical fitness values in children from northern Spain. J Sport Heal Res., 9(2), 211-222. http://www.journalshr.com/papers/Vol%209_N%202/JSHR%20V09_2_3.pdf

Arriscado, D., Muros, J.J., Zabala, M., & Dalmau, J.M. (2015). Physical activity habits in schoolchildren: influential factors and relationships with physical fitness. Nutr Hosp., 31(3), 1232-1239. http://dx.doi.org/10.3305/nh.2015.31.3.8186

Basterfield, L., Pearce, M.S., Adamson, A.J., Frary, J.K., Parkinson, K.N., Wright CM, & Reilly, J.J. (2012). Physical activity, sedentary behavior, and adiposity in English children. Am J Prev Med., 42(5), 445-451. https://doi.org/10.1016/j.amepre.2012.01.007

Benítez-Porres, J., Albero-cruz, J.R., Sardinha, L.B., López-fernández, I., & Carnero, E.A. (2016). Cut-off values for classifying active children and adolescentes using the Physical Activity Questionnaire: PAQ-C and PAQ-A. Nutr Hosp., 33(5), 1036-1044. https://doi.org/10.20960/nh.564

Brouwer, S.I., Stolk, R.P., Liem, E.T., Lemmink, K.A.P.M., & Corpeleijn, E. (2013). The role of fitness in the association between fatness and cardiometabolic risk from childhood to adolescence. Pediatr Diabetes., 14, 57-65. https://doi.org/10.1111/j.1399-5448.2012.00893.x

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.P., Chastin, S., Chou, R., Dempsey, P.C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C., García, L., Gichu, M., Jago, R., Katzmarzyk, P.T., …Willumsen, J.F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med., 54(24), 1451-1462. https://doi.org/10.1136/bjsports-2020-102955

Casajús, J.A., Ortega, F.B., Vicente-Rodríguez, G., Leiva, M.T., Moreno, L.A., & Ara, I. (2012). Physical fitness, fat distribution and health in school-age children (7 to 12 years). Rev. int. med. cienc. act. fís. Deporte, 12(47), 523-537.

Casas, A.G., García, P.L.R., Guillamón, A.R., García-Canto, E., Soto, J.J.P., Marcos, M.L.T., & Tárraga, P.J. (2014). Physical fitness level and its relationship with body weight status in school children. Nutr Hosp., 31(1), 393-400. https://doi.org/10.3305/nh.2015.31.1.8074

Castro-Piñeiro, J., González-Montesinos, J.L., Mora, J., Keating, X.D., Girela-Rejón, M.J., Sjöström, M., & Ruiz, J.R. (2009). Percentile values for muscular strength field tests in children aged 6 to 17 Years: Influence of weight status. J Strength Cond Res., 23(8), 2295-310. https://doi.org/10.1519/JSC.0b013e3181b8d5c1

Castro-Piñeiro, J., Ortega, F.B., Keating, X.D., González-Montesinos, J.L., Sjöstrom, M., & Ruiz, J.R. (2011). Percentile values for aerobic performance running/walking field tests in children aged 6 to 17 years; influence of weight status. Nutr Hosp., 26(3), 572-578. http://scielo.isciii.es/pdf/nh/v26n3/21_original_17.pdf

Castro-Piñero, J., Perez-Bey, A., Segura-Jiménez, V., Aparicio, V.A., Gómez-Martínez, S., Izquierdo-Gomez, R., Marcos, A., & Ruiz, J.R. (2017). Cardiorespiratory Fitness Cutoff Points for Early Detection of Present and Future Cardiovascular Risk in Children: A 2-Year Follow-up Study. Mayo Clin Proc., 92(12), 1753-1762. https://doi.org/10.1016/j.mayocp.2017.09.003

Cepero, M., López, R., Suárez-Llorca, C., Andreu-Cabrera, E., & Rojas, F. (2011). Fitness test profiles in children aged 8-12 years old in Granada (Spain). J Hum. Sport and Exerc., 6(1), 135-145. https://doi.org/10.4100/jhse.2011.61.15

Chacón-Borrego, F., Corral-Pernía, J.A., & Castañeda-Vázquez, C. (2020). Condición física en jóvenes y su relación con la actividad física escolar y extraescolar. Rev Interuniv Form del Profesorado, 34(1), 99-114. https://doi.org/10.47553/rifop.v34i1.77077

Chaput, J.P., Lambert, M., Mathieu, M.E., Tremblay, M.S., O'Loughlin, J., & Tremblay, A. Physical activity vs. sedentary time: Independent associations with adiposity in children. Pediatr Obes., 7(3), 251-258. https://doi.org/10.1111/j.2047-6310.2011.00028.x

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd edition). Lawrence Earlbaum Associates.

Cureton, K.J., Plowman S.A., & Mahar, M.T. (2013). Fitnessgram /Activitygram. Reference Guide, 4th ed. The Cooper Institute.

Dencker, M., Wollmer, P., Karlsson, M. K., Lindén, C., Andersen, L. B., & Thorsson, O. (2011). Body fat, abdominal fat and body fat distribution related to VO2PEAK in young children. Pediatr Obes., 6(2), e597-602. https://doi.org/10.3109/17477166.2010.526612

Díez-Fernández, A., Sánchez-López, M., Mora-Rodríguez, R., Notario-Pacheco, B., Torrijos-Niño, C., & Martínez-Vizcaíno, V. (2014). Obesity as a mediator of the influence of cardiorespiratory fitness on cardiometabolic risk: a mediation analysis. Diabetes Care, 37(3), 855-862. https://doi.org/10.2337/dc13-0416

Ekelund, U., Sardinha, L.B., Anderssen, S.A., Harro, M., Franks, P.W., Brage, S., Cooper, A.R., Andersen, L.B., Riddoch, C., Froberg, K. (2004). Associations between objectively assessed physical activity and indicators of body fatness in 9- to 10-y-old European children: A population-based study from 4 distinct regions in Europe (the European Youth Heart Study). Am J Clin Nutr., 80(3), 584-590. https://doi.org/10.1093/ajcn/80.3.584

Flood, J. E., Roe, L. S., & Rolls, B. J. (2006). The effect of increased beverage portion size on energy intake at a meal. J Am Diet Assoc., 106, 1984-1990. https://doi.org/10.1016/j.jada.2006.09.005

Fundación para la Investigación Nutricional. (2018). Informe 2018: Actividad Física en niños y adolescentes en España. Fundación para la Investigación Nutricional. Generalitat de Catalunya, Departament de Salut (2016). Informe 2015 de l'Enquesta de salut de Catalunya (ESCA). ESCA.

Goldfield, G.S., Harvey, A., Grattan, K., & Adamo, K.B. (2012). Physical activity promotion in the preschool years: A critical period to intervene. Int J Environ Res Public Health, 9(4), 1326-1342. https://doi.org/10.3390/ijerph9041326

Guillamón, A.R., García-Cantó, E., Pérez Soto, J.J., & Rodríguez García, P.L. (2015). Aerobic capacity and its relationship with parameters of health-related fitness in schoolchildren. Rev. Fac. Cienc. Salud UDES., 2(2), 90-6. https://doi.org/10.20320/rfcsudes.v2i2.58

Gutin, B., Barbeau, P., Owens, S., Lemmon, C.R., Bauman, M., Allison, J., Kang, H.S., & Litaker, M.S. (2002). Effects of exercise intensity on cardiovascular fitness, total body composition, and visceral adiposity of obese adolescents. Am J Clin Nutr., 75(5), 818-826. https://doi.org/10.1093/ajcn/75.5.818

He, Q.Q., Wong, T.W., Du, L., Jiang, Z.Q., Yu, T.S., Qiu, H., Gao, Y., Liu, W.J., & Wu, J.G. (2011). Physical activity, cardiorespiratory fitness, and obesity among Chinese children. Prev Med., 52(2), 109-13. https://doi.org/10.1016/j.ypmed.2010.11.005

Hernández, R., Fernández, C., & Baptista, M.P. (2014). Metodología de la investigación. Mc Graw Hill Education.

Jiménez-Pavón, D., Kelly, J., & Reilly, J.J. (2010). Associations between objectively measured habitual physical activity and adiposity in children and adolescents: Systematic review. Int. J. Pediatr. Obes., 5(1), 3-18. https://doi.org/10.3109/17477160903067601

Kalman M., Inchley J., Sigmundova D., Iannotti R.J., Tynjälä, J.A., Hamrik, Z., Haug, E., & Bucksch, J. (2002). Secular trends in moderate-to-vigorous physical activity in 32 countries from 2002 to 2010: a cross-national perspective. Eur J Public Health., 25(2), 37-40. https://doi.org/10.1093/eurpub/ckv024

Kodama, S., Saito, K., Tanaka, S., Maki, M., Yachi, Y., Asumi, M., Sugawara A., Totsuka, K., Shimano, H., Ohashi, Y., Yamada, N., & Sone, H. (2009). Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: A meta-analysis. JAMA -J Am Med Assoc., 301(19), 2024-35. https://doi.org/10.1001/jama.2009.681

Kowalski, K.C., Crocker, P.R.E., & Donen, R.M. (2004). The Physical Activity Questionnaire for Older Children (PAQ-C) and Adolescents (PAQ-A) Manual. College of Kinesiology University of Saskatchewan.

Lee, S.T., Wong, J.E., Shanita, S.N., Ismail, M.N., Deurenberg, P., & Poh, B.K. (2015). Daily physical activity and screen time, but not other sedentary activities, are associated with measures of obesity during childhood. Int J Environ Res Public Health, 12(1), 146-161. https://doi.org/10.3390/ijerph120100146

Liew, J., Xiang, P., Johnson, A. Y., & Kwok, O. M. (2011). Effortful persistence, and body mass as predictors of running achievement in children and youth: A longitudinal study. J Phys Act Health, 8(2), 234-243. https://doi.org/10.1123/jpah.8.2.234

Lopez-Sanchez, G.F., Nicolas-Lopez, J., & Diaz-Suarez, A. (2016). Effects of a program of intense physical activity on the body composition of adolescents from Murcia. SportTk: Revista Euroam de Ciencias del Deporte, 5(2), 83-88. https://doi.org/10.6018/264711

Manchola-González, J., Bagur-Calafat, C., & Girabent-Farrés, M. (2017). Reliability of the Spanish Version of Questionnaire of Physical Activity PAQ-C. Rev Int Med y Ciencias la Act Física y del Deport., 65, 139-152. https://doi.org/10.15366/rimcafd2017.65.010

Martínez-Martínez, J., De los Reyes-Corcuera, M., Borrell-Lizana, V., & Pastor-Vicedo, J.C. (2018). Assessment of the physical condition levels of school children aged 11-12 years, through the application of the ALPHAFITNESS Battery. SportTK-Revista Euroam de Ciencias del Deporte, 7(2), 37-42. https://doi.org/10.6018/sportk.343211

McCarthy, H.D., Cole, T.J., Fry, T., Jebb, S.A., & Prentice, A.M. (2006). Body fat reference curves for children. Int J Obes., 30, 598-602. https://doi.org/10.1038/sj.ijo.0803232

Migueles JH, Cadenas-Sanchez C, Ekelund U, Nyström, C.D., Mora-González, J., Löf, M., Labayen, I., Ruiz, J., & Ortega, F.B. (2017). Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations. Sports medicine, 47, 1821-1845. https://doi.org/10.1007/s40279-017-0716-0

Moliner-Urdiales, D., Ruiz, J.R., Vicente-Rodriguez, G., Ortega, F.B., Rey-Lopez, J.P., España-Romero, V., Casajús, J.A., Molnar, D., Widhalm, K., Dallongeville, J., González-Gross, M., Castillo, M.J., Sjöström, M., & Moreno, L.A. (2011). Associations of muscular and cardiorespiratory fitness with total and central body fat in adolescents: The HELENA study. Br J Sports Med., 45, 101-108. https://doi.org/10.1136/bjsm.2009.062430

Moreno, L.A., Mesana, M.I., González-Gross, M., Gil, C.M., Fleta, J., Wärnberg, J.R., Ruiz, J., Sarría, A., Marcos, A., Bueno, M., & and the AVENA Study Group. (2006). Anthropometric body fat composition reference values in Spanish adolescents. The AVENA Study. Eur J Clin Nutr., 60, 191-196. https://doi.org/10.1038/sj.ejcn.1602285

Murillo, B., García-Bengoechea, E., Generelo, E., Bush, P. L., Zaragoza, J., Julián-Clemente, J. A., & García-González, L. (2013). Promising school-based strategies and intervention guidelines to increase physical activity of adolescents. Health Education Research, 28, 523-538. https://doi.org/10.1093/her/cyt040

Ortega, F.B., Artero, E.G., Ruiz, J.R., España-Romero, V., Jiménez-Pavón, D., Vicente-Rodríguez, G., Moreno, L.A., Manios, Y., Béghin, L., Ottevaere, C., Ciarapica, D., Sarri, K., Dietrich, S., Blair, S.N., Kersting, M., Molnar, D., González-Gross, M., Gutiérrez, A., Sjöström, M., & Castillo, M.J. (2011). Physical fitness levels among European adolescents: the HELENA study. Br J Sports Med., 45, 20-29. https://doi.org/10.1136/bjsm.2009.062679

Ortega, F.B., Ruiz, J.R., & Castillo, M.J. (2012). Physical activity, physical fitness, and overweight in children and adolescents: evidence from epidemiologic studies. Endocrinol y Nutr., 60(8), 458-469. https://doi.org/10.1016/j.endonu.2012.10.006

Ortega, F.B., Ruiz, J.R., Castillo, M.J., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: A powerful marker of health. Int J Obes., 32, 1-11. https://doi.org/10.1038/sj.ijo.0803774

Roman-Viñas, B., Zazo, F., Martínez-Martínez, J., Aznar-Laín, S., & Serra-Majem, L. (2018). Results from Spain's 2018 report card on physical activity for children and youth. J of Physical Activity and Health, 15(s2), S411-S412. https://doi.org/10.1123/jpah.2018-0464

Rosa-Guillamón, A., Rodríguez-García, P., García-Cantó, E., & Pérez-Soto, J. (2015). Physical fitness levels of school children aged 8 to 11 years in relation to gender and nutritional status. Agora for PE and Sport, 17(3), 237-250.

Ruiz, E., Ávila, J.M., Castillo, A., Valero, T., del Pozo, S., Rodriguez, P., Bartrina, J.A., Gil, Á., González-Gross, M., Ortega, R.M., Serra-Majem, L., & Varela-Moreiras, G. (2015). The ANIBES study on energy balance in Spain: Design, protocol and methodology. Nutrients, 7(2), 970-998. https://doi.org/10.3390/nu7020970

Ruiz, J.R., España, V., Castro, J., Artero, E.G., Ortega, F.B., Cuenca, M., Jiménez, D., Chillón, P., Girela, M.J., Mora, J., Gitérrez, A., Suni, J., Sjöstrom, M., & Castillo, M.J. (2011). ALPHA-fitness: test battery health related field based fitness tests assessment in children and adolescents. Nutr Hosp., 26(6), 1210-1214. http://www.nutricionhospitalaria.com/pdf/5270.pdf

Rundle, A.G., Park, Y., Herbstman, J.B., Kinsey, E.W., & Wang, Y.C. (2020). COVID-19-Related School Closings and Risk of Weight Gain Among Children. Obesity, 28(6), 1008-1009. https://doi.org/10.1002/oby.22813

Rush, E., McLennan, S., Obolonkin, V., Vandal, A.C., Hamlin, M., Simmons, D., & Graham, D. (2014). Project energize: Whole-region primary school nutrition and physical activity programme; evaluation of body size and fitness 5 years after the randomised controlled trial. Br J Nutr., 111(2), 363-371. https://doi.org/10.1017/S0007114513002316

Secchi, J.D., García, G.C., España-Romero, V., & Castro-Piñero, J. (2014). Physical fitness and future cardiovascular risk in argentine children and adolescents: an introduction to the ALPHA test battery. Arch Argent Pediatr., 112(2), 132-140. https://doi.org/10.5546/aap.2014.132

Wang, P. G., Gong, J., Wang, S. Q., Talbott, E. O., Zhang, B., & He, Q. Q. (2011). Relationship of body fat and cardiorespiratory fitness with cardiovascular risk in Chinese children. PLoS One, 6(11), e27896. https://doi.org/10.1371/journal.pone.0027896

World Health Organization. (2006). WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. WHO Child Growth Standards. 2006. Available online: https://www.who.int/publications/i/item/924154693X (accessed on 24 February 2021).

Yin Y. (2020). Model-free tests for series correlation in multivariate linear regression. J Stat Plan Inference, 206, 179-95. https://doi.org/10.1016/j.jspi.2019.09.011

Zhu, Q., Li, M., Ji, Y., Shi, Y., Zhou, J., Li, Q., Qin, R., & Zhuang, X. (2021). "Stay-at-Home" Lifestyle Effect on Weight Gain during the COVID-19 Outbreak Confinement in China. Int. J. Environ. Res. Public Health, 18(4), 1813. https://doi.org/10.3390/ijerph18041813