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Original/*Deporte y ejercicio*

Anthropometric characteristics and physical fitness level in relation to body weight status in Chilean preschool children

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Abstract

The purpose of this study was to describe anthropometric and physical fitness characteristics of low-income Chilean preschool children and to examine whether weight status influences children's performance on fitness tests. A total of 434 preschool children (246 boys; 5.48 ± 0.31 years) participated in our study. Anthropometry (weight, height, body mass index -BMI- and waist circumference) and fitness tests (handgrip strength test, standing long jump and 20 m sprint) were assessed by trained nutritionists and physical education teachers, respectively. Significant differences in anthropometry and fitness tests between boys and girls were found. The prevalence of overweight was higher in girls; in contrast to that of obesity. Compared to normal-weight children, overweight/obese boys and girls were heavier and had greater waist circumference (P<0.001), were taller (P≤0.002), and showed higher performance in handgrip strength (P≤0.027) but not in standing long jump nor 20 m sprint (P≥0.052). Screening physical fitness levels in overweight/obese preschool children could be an important tool in order to design an efficacy physical activity programme.

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Key words: *BMI. Overweight. Muscular strength. Speed. Preschoolers.*

CARACTERÍSTICAS ANTROPOMÉTRICAS Y NIVEL DE CONDICIÓN FÍSICA EN RELACIÓN CON EL ESTADO PONDERAL EN NIÑOS CHILENOS DE EDAD PREESCOLAR

Resumen

El objetivo de este estudio fue describir las características antropométricas y el nivel de condición física de preescolares chilenos de bajo nivel socioeconómico y examinar si el estado ponderal influye en el rendimiento de los niños en las pruebas de condición física. Un total de 434 preescolares (246 niños; 5,48 ± 0,31 años) participaron en nuestro estudio. Antropometría (peso, talla, índice de masa corporal –IMC– y perímetro de cintura) y tests de condición física (test de fuerza de prensión manual, test de salto de longitud y 20 m sprint) fueron evaluados por nutricionistas entrenados y profesores de educación física, respectivamente. Se encontraron diferencias significativas en antropometría y tests de condición física entre niños y niñas. La prevalencia de sobrepeso fue mayor en las niñas; en contraste con la de la obesidad. En comparación con los preescolares con normopeso, los niños y niñas con sobrepeso/obesidad pesaron más y tuvieron mayor perímetro de cintura (P<0.001), eran más altos (P≤0.002) y mostraron mayor rendimiento en el test de fuerza de prensión manual (P≤0.027), pero no en el test de salto de longitud ni en el test de sprint de 20 m (P≥0.052). Detectar los niveles de condición física en preescolares con sobrepeso/obesidad puede ser una herramienta importante para diseñar programas eficaces de actividad física.

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Palabras clave: *IMC. Sobrepeso. Fuerza muscular. Velocidad. Preescolares.*

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Abbreviations:

OECD: Organisation for Economic Co-operation and Development.
ANOVA: Analysis of variance.
ANCOVA: Analysis of covariance.
MD: Mean difference.
SD: Standard deviation.

Introduction

Childhood overweight and obesity has dramatically increased worldwide in recent decades and it is one of the most serious public health challenges of the twenty-first century[1]. According to the Organization for Economic Co-operation and Development (OECD) Health data, Chile has one of the highest childhood obesity rates, together with Mexico, United States and several European countries (e.g. Italy, Greece)[2]. This trend is alarming because it has been shown that overweight/obesity in young children is associated with cardio-metabolic risk factors and worse mental and physical health such as cognition, academic achievement and/or physical fitness[3-5].

Physical fitness (mainly cardiorespiratory fitness and muscular strength) during childhood and adolescence is a powerful marker of future health[6, 7]. Despite the beneficial health effects, secular trends in physical fitness reveal that the level of aerobic fitness and muscular strength decrease 0.4%[8] and 2.0%[9] per year, respectively. It has been recently suggested that preschool children show a marked decline in activity from 3 to 4 years of age, which is maintained until the age of 7[10]. The low activity levels observed in childhood might be responsible of the high prevalence of overweight/obesity and low fitness levels reported among European adolescents[11,12]. In Chile, data available on the prevalence of overweight/obesity in preschool children shows that it is very high, around 40%[13], nevertheless their fitness level is largely unknown.

In adolescents, the relation between weight status and physical fitness has been well established. Overall, normal weight adolescents present better physical fitness (i.e. muscular strength, cardiorespiratory fitness and speed-agility) than underweight and overweight/obese adolescents[14-18]. In a study examining 6929 Chinese (6-12 years) children, authors observed no significant difference in fitness tests between underweight and normal weight preschool children compared to their overweight counterparts[19]. A recent study found that normal weight 5 year-old Swiss children performed better than overweight children in aerobic fitness, agility and dynamic balance while overweight children had a better static balance[20]. In contrast, Bonvin et al. observed that there were no significant differences in global motor skills (measured by obstacle course and skills from the Zurich Neuromotor Assessment test) in 2- to 4-year-old preschoolers according to weight status[21].

Given the importance of assessing both anthropometry and physical fitness at early ages in order to promote health behaviors, and considering that this information is scarce in Chilean preschoolers, the purpose of this study is to describe the anthropometric characteristics and physical fitness level of low-income Chilean preschool children and to examine whether weight status influences children's performance on fitness tests.

Methods

Participants

A total of 434 low-income preschool children (5.48 ± 0.31 years) who attended kindergarten at 10 public elementary schools located in a district of Santiago (Chile) participated in our study. Public schools in Chile are categorized by an index called "vulnerability index" which is related to several social indicators of their students. The vulnerability index of the schools where the sample was selected indicates that the children belong to the lower- income segment of the population[22].

The present study shows the baseline data of an ongoing obesity prevention intervention. Anthropometry and fitness tests were assessed by trained nutritionists and physical education teachers in April 2013. Parents or a legal representative signed an informed consent form after being told about the purpose of the study. The study protocol was performed following the ethical guidelines of the Declaration of Helsinki 1961 (revision of Edinburgh 2013) and consent forms were approved by the Ethics Committee for Human Studies of the Institute of Nutrition and Food Technology (INTA) of the University of Chile.

Measures

Anthropometrics measures

Weight was measured with a portable digital scale (SECA 804, Hamburg, Germany) with a precision of 0.1 kg, height with a portable stadiometer (SECA 213, Hamburg, Germany) to the nearest 0.1 cm, while waist circumference was measured over the rim of the iliac crest, through the umbilicus with an inextensible, metal, self-locking tape (Lufkin W606PM; CooperTools, Raleigh, North Carolina), with an accuracy of 0.1 cm. Body mass index (BMI) was calculated as weight (kg) / height (m)^2 and participants were classified as underweight, normal weight, overweight or obese following the WHO reference 2007[23].

Fitness tests

Explosive strength of the lower limbs was assessed by *standing long jump*. This test consisted of jumping

as far as possible with the feet together and remaining upright. The distance was measured from the take-off line to the point where the back of the heel nearest to the take-off line lands on the ground. The best of two attempts was recorded in centimetres (cm).

Upper muscular strength was evaluated by *handgrip strength test* using a Jamar hydraulic hand dynamometer (J.A. Preston Corporation, Clifton, NJ, USA). The child was seated with shoulders adducted and neutrally rotated, elbow flexed at 90º, wrist flexed between 0º and 30º and between 0º and 15º of ulnar deviation[24]. The handle of the device was set to the first position (i.e. 3.5 cm). The test was performed three times (alternately with both hands) and allowing approximately a 30 seconds rest period between measures. The best score of each hand was chosen and the average of the greatest score of both hands was recorded in kilograms (kg).

Speed was measured by *20 m sprint test*. Preschool children performed a 20 m sprint with the start line and finish line clearly marked. Participants were instructed to run as fast as possible. One evaluator was positioned at the finish line. The test finished when the participants crossed the end line. The result was measured with a stopwatch to the nearest of 0.1 seconds. A higher score indicates a worse performance (lower speed). The test was performed twice, with 60 seconds between measurements. The fastest time (seconds) was used in the analysis.

Statistical analysis

Descriptive analyses and percentiles of anthropometric and fitness variables were calculated to determine the distribution of the sample 5th, 25th, 50th, 75th and 95th by sex. We also performed an exploratory analysis in order to determine the percentiles of fitness tests by weight status and sex. To test whether there were differences between sex, we used analysis of variance (ANOVA) with sex as fixed factor and anthropometric and fitness measures as dependent variables. Nominal variables such as weight status were analysed using Chi-squared test. To test differences in anthropometry and fitness variables between normal weight and overweight/obese boys and girls, we used analysis of covariance (ANCOVA) with age as a confounder. In order to compare anthropometric and fitness variables and observe in which test the effect size was higher, we calculated sex specific z-scores (i.e. value - mean/standard deviation).

Because there were significant and borderline interactions in anthropometric and fitness measures by sex, except for BMI scores, the data from the main analyses are presented separately for boys and girls, except for BMI, which is presented for the total sample. All the statistical analyses were performed using SPSS software (version 20.0, IBM Corpora-

Table I
Anthropometric and fitness characteristics of low-income Chilean preschool children (total sample and by sex)

	All			*Boys*			*Girls*			P_{sex} ‡
	N	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	
Age (years)	434	5.48	0.31	246	5.49	0.32	188	5.48	0.30	0.898
Anthropometry										
Weight (kg)	434	21.90	3.78	246	22.24	4.12	188	21.47	3.23	0.036
Height (cm)	434	112.28	4.51	246	112.65	4.62	188	111.80	4.33	0.051
BMI (Kg/m^2)*	434	17.29	2.18		-			-		-
WC (cm)	431	56.13	5.57	243	56.57	5.98	188	55.55	4.95	0.058
Weight z-score	434	0.81	1.13	246	0.90	1.27	188	0.69	0.92	0.048
Height z-score	434	-0.03	0.87	246	-0.03	0.92	188	-0.05	0.81	0.809
BMI z-score	434	1.19	1.22	246	1.33	1.37	188	1.00	0.97	0.005
Normal weight (%)	209	48.16		110	44.72		99	52.66		0.012
Overweight (%)	126	29.03		67	27.24		59	31.38		
Obese (%)	99	22.81		69	28.05		30	15.96		
Physical fitness										
Handgrip (kg)	434	7.73	1.68	246	8.07	1.66	188	7.29	1.61	<0.001
Standing long jump (cm)	422	80.24	15.91	243	84.49	15.60	179	74.48	14.50	<0.001
20 m sprint (s)†	432	5.60	0.69	246	5.45	0.63	186	5.80	0.71	<0.001

SD= Standard Deviation.
*BMI is presented for the entire sample due to absence of interaction by sex.
†In this test, the lower the score (in seconds) the higher the performance.
‡Differences between boys and girls were examined by analysis of variance (ANOVA), except for weight status (chi-squared test).

Table II
Percentile values for anthropometric characteristics and physical fitness tests in 5 year-old preschool Chilean children, by sex

	Percentiles				
	5th	25th	50th	75th	95th
All					
BMI*	14.54	15.83	16.87	18.33	21.48
Boys					
Weight (kg)	17.24	19.40	21.40	24.03	30.40
Height (cm)	105.00	109.20	112.55	115.85	120.57
Waist Circumference (cm)	49.42	52.60	55.50	58.80	68.98
Handgrip (kg)	5.40	6.95	7.93	9.15	10.68
Standing long jump (cm)	57.40	74.00	84.00	96.00	109.00
20 m sprint (s)	4.70	5.00	5.40	5.70	6.60
Handgrip/weight	0.24	0.32	0.36	0.42	0.50
Girls					
Weight (kg)	17.10	19.10	21.00	23.40	27.21
Height (cm)	104.35	108.63	111.90	114.58	119.00
Waist Circumference (cm)	48.73	52.03	55.00	57.98	65.40
Handgrip (kg)	5.10	6.10	7.13	8.39	10.11
Standing long jump (cm)	53.00	65.00	74.00	85.00	98.00
20 m sprint (s)†	4.90	5.30	5.65	6.20	7.10
Handgrip/weight	0.23	0.29	0.34	0.4	0.47

*BMI is presented for the entire sample due to absence of interaction by sex.
†In this test, the lower the score (in seconds) the higher the performance.

tion). The level of significance was set at $p<0.05$ for all analyses.

Results

Descriptive characteristics of anthropometry and physical fitness variables of the whole sample and stratified by sex are presented in table I as means and standard deviation. Anthropometric variables show that boys were heavier and taller compared to girls (Mean difference, MD = 0.77±0.36 kg and 0.85±0.44 cm, respectively; P≤0.051). Waist circumference presented a borderline non-significant differences between sex (MD = 1.03±0.54; P=0.058). Due to this borderline situation, we decided to present waist circumference data separately by sex. Comparing our results with WHO reference data[23], we observed that, both boys and girls, showed a weight and a BMI z-score above the mean (Boys= 0.90 and 1.33 and girls= 0.69 and 1.00, respectively). The prevalence of overweight was higher in girls than in boys (31.4% versus 27.2%), while this pattern was opposite in the case of obesity (i.e. higher in boys than in girls, 28.0% versus 15.9%; P=0.012).

In regards to fitness, boys performed better in upper-muscular strength test (i.e. handgrip), lower-muscular strength test (i.e. standing long jump) and speed test (i.e. 20 m sprint) than girls (MD = 0.78±0.16 kg, 10.00±1.50 cm and -0.35±0.07 s, respectively; P<0.001 for all). Percentiles values (5th, 25th, 50th, 75th and 95th) for anthropometry and fitness tests for boys and girls are shown in table II. Supplementary material (Table SI and table SII) show the percentile values of fitness tests stratified by weight status (i.e. normal weight versus overweight/obese) for boys and girls.

Differences in anthropometric characteristics and fitness tests between normal weight and overweight/obese children are shown in table III. Differences were observed in weight, height, waist circumference and handgrip strength both in boys and girls. However, no differences were observed in standing long jump or 20 m sprint. All models were adjusted for age. Fitness z-scores by sex comparing normal weight and overweight/obese groups are shown in figure 1. Overweight/obese boys and girls showed values of upper-muscular strength above the mean whilst the opposite occurred in normal weight preschool children. No differences were observed in lower muscular strength and speed between weight status groups both in boys and in girls (P<0.05).

Table SI
Percentile values for physical fitness tests by weight status in 5 year –old Chilean boys

	Percentiles				
	5th	*25th*	*50th*	*75th*	*95th*
Normal weight					
Handgrip (kg)	5.30	6.85	7.70	8.90	10.47
Standing long jump (cm)	62.45	76.00	85.50	99.75	109.00
20 m sprint (s)	4.60	5.00	5.35	5.70	6.73
Overweight/Obese					
Handgrip (kg)	5.40	7.30	8.25	9.30	11.36
Standing long jump (cm)	56.80	73.00	82.00	94.00	107.20
20 m sprint (s)*	4.70	5.10	5.40	5.78	6.62

*In this test, the lower the score (in seconds) the higher the performance.

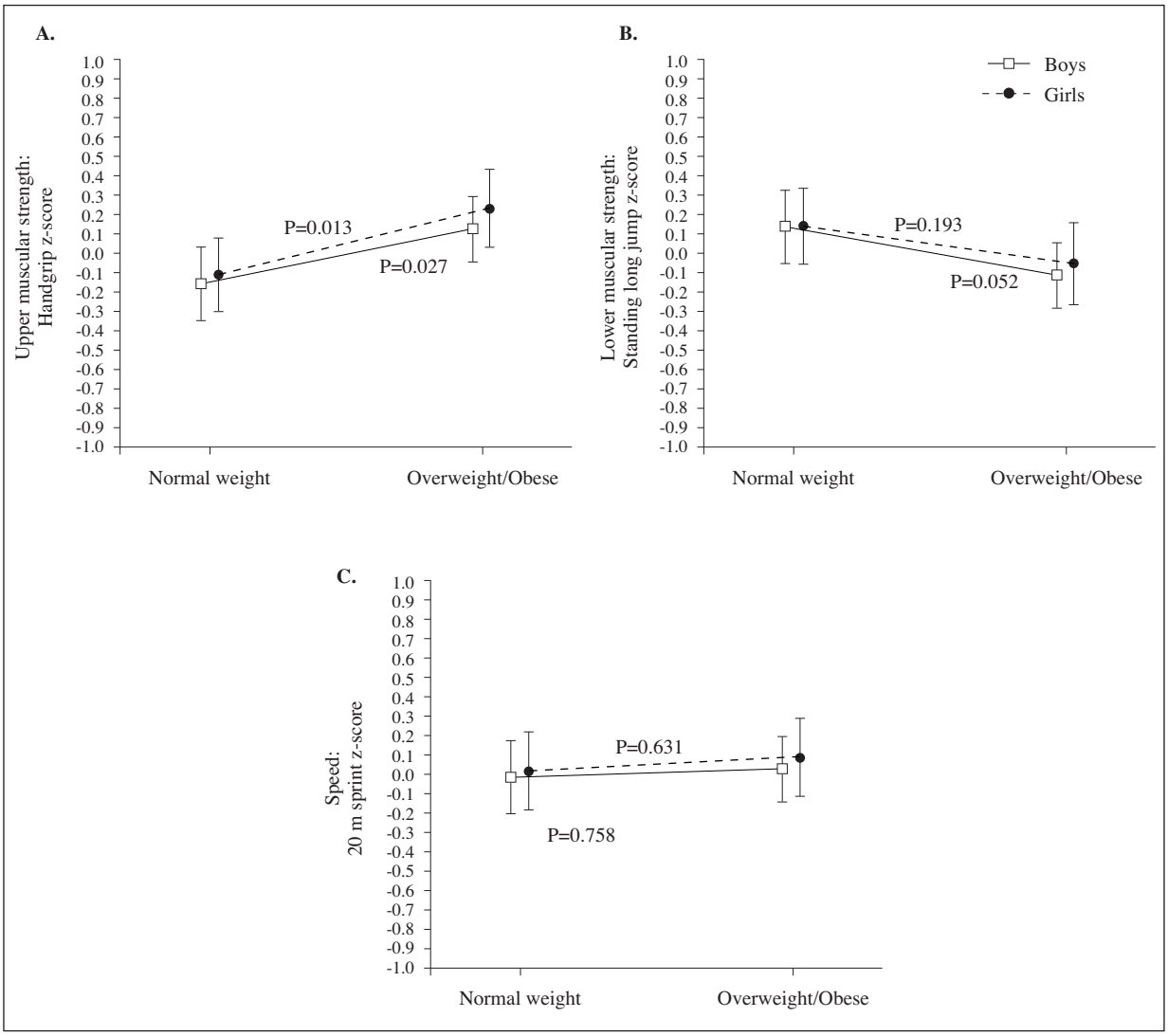

Fig. 1.—Z-score differences in upper muscular strength (Figure 1a), lower muscular strength (Figure 1b) and speed (Figure 1c) between normal weight and overweight/obese boys and girls. Analysis of covariance (ANCOVA) model was adjusted for age. A z-score of 0 means the score is the same as the mean. A positive or negative z-score indicates that the participants' score is above or below the mean, respectively.

Table SII
Percentile values for physical fitness tests by weight status in 5 year –old Chilean girls

	Percentiles				
	5th	25th	50th	75th	95th
Girls					
Normal weight					
Handgrip (kg)	4.85	6.00	6.85	7.85	10.00
Standing long jump (cm)	51.50	65.75	76.50	85.00	100.75
20 m sprint (s)	4.80	5.30	5.60	6.20	7.16
Overweight/Obese					
Handgrip (kg)	5.23	6.13	7.55	8.70	11.08
Standing long jump (cm)	54.30	62.00	72.00	83.00	97.40
20 m sprint (s)*	5.00	5.30	5.70	6.25	7.05

*In this test, the lower the score (in seconds) the higher the performance.

Tabla III
Differences in anthropometric characteristics and fitness tests between normal weight and overweight/obese 5 year-old preschool children

	Normal weight			Overweight/Obese			P*
	n	Mean	SEM	n	Mean	SEM	
Boys							
Weight (kg)	110	19.44	0.31	136	24.50	0.28	**<0.001**
Height (cm)	110	111.59	0.47	136	113.51	0.37	**0.001**
Waist circumference (cm)	108	52.63	0.47	135	59.73	0.42	**<0.001**
Handgrip strength (kg)	110	7.81	0.17	136	8.28	0.14	**0.027**
Standing long jump (cm)	108	86.66	1.49	135	82.76	1.33	0.052
20 m sprint (s)†	110	5.44	0.06	136	5.47	0.54	0.758
Girls							
Weight (kg)	99	19.42	0.23	89	23.75	0.24	**<0.001**
Height (cm)	99	110.96	0.39	89	112.74	0.41	**0.002**
Waist circumference (cm)	99	52.44	0.37	89	59.00	0.39	**<0.001**
Handgrip strength (kg)	99	7.03	0.15	89	7.59	0.16	**0.013**
Standing long jump (cm)	94	75.81	1.47	85	73.01	1.55	0.193
20 m sprint (s)†	97	5.78	0.71	89	5.83	0.08	0.631

Values presented as adjusted means. SEM = Standard error of the mean.
*Analysis of covariance (ANCOVA). Models were adjusted for age.
†In this test, the lower the score (in seconds) the higher the performance.

Discussion

The main findings of this study were: 1) There were differences in anthropometric measures and fitness tests between boys and girls; 2) The prevalence of overweight was higher in girls than in boys, while the opposite was found for obesity; 3) We provide percentile values for anthropometric measures and fitness tests in Chilean preschool boys and girls; 4) Overweight/obese preschoolers boys and girls present higher values for weight and waist circumference, are taller, and show better performance in handgrip strength but not in standing long jump nor 20 m sprint, compared with normal weight preschoolers.

Descriptive characteristics in our sample showed that boys are heavier and taller than girls, but no differences were observed in BMI, which is consistent with what other authors have found when examining the evolution of anthropometric characteristics from birth to 5 years of age in Chilean preschool children[25]. The

prevalence of overweight in our study (all = 29.0%; boys = 27.2%; girls = 31.4%) was higher than in China (boys = 18.5%; girls = 12.4%)[19]. The same pattern occurred with the prevalence of obesity as in our sample these rates are higher (all = 22.8%; boys = 28.1%; girls = 15.9%) compared with the Chinese sample (boys = 9.5%; girls = 3.4%)[19]. Although the Germany sample used different cut-off points to determine the nutritional status, the prevalence of overweight/obese preschool children was significantly lower compared to our results (19.0% versus 51.9%)[20]. In addition, comparing our results with the OECD overweight/obesity rates, we observe that the prevalence of overweight/obesity in our sample is 20.0-26.0% higher, both in boys as in girls[2]. This difference could be due that the OECD data includes preschool children of all socioeconomic conditions, while children in our sample are best described as belonging to a low-income strata; in this regard, it has been shown that the rate of childhood overweight/obesity is higher among lower socioeconomic groups[26].

Likewise, the present study provides percentile values of anthropometric and fitness tests in low-income Chilean preschoolers aged 5 years. Having percentiles values for different anthropometric measures and some fitness tests, such as strength and speed performance in young children, may help identify problems or deficiencies in tests (e.g. low fitness levels, high BMI) and thus, promote health behaviours such as increasing time in physical activity or following healthier dietary patterns. In line with this affirmation, the American Heart Association emphasizes the role of schools in promoting healthy lifestyles among young population[27].

In regard to fitness, few studies have been conducted in this age group and their results are controversial because different tests have been used[19-21,28]. Our results showed fitness differences between weight status categories (i.e. normal weight versus overweight/obese). Particularly, in agreement with other studies in children and adolescents[14,18], normal weight group showed lower upper-muscular strength (i.e. handgrip) compared to those counterparts from overweight/obese group. However, for standing long jump and 20 m sprint, we observed no significant differences between weight status groups although the results were slightly better for normal weight than overweight/obese. In agreement with our results, De Toia et al.[28] found no differences among normal weight and overweight children in standing long jump test. Nevertheless, it is interesting to highlight the borderline non-significance result of standing long jump in boys (P= 0.052). This finding further supports the idea of weight-bearing tests (i.e. standing long jump and 20 m sprint) which requires propulsion or lifting of body, is a disadvantage in overweight and obese children due to extra body load to be moved while performing these tests[14,29]. Yet, overweight/obese children can perform better non weight-bearing tests (tests where their body does not have to be moved) such as handgrip strength[14].

Several limitations to this study need to be acknowledged. The sample was restricted to low-income Chilean preschool children, thus, our results only apply to this group. Another limitation was that few fitness tests were used, which means that other components of fitness, such as cardiorespiratory fitness and balance were not assessed. It would have been appropriate to incorporate other fitness tests such as those proposed by Ortega et al. in the PREFIT study, so as to be able to compare our results to those obtained among European preschool children[30,31]. The possibility of characterizing and calculating percentiles of a relatively large sample of low-income preschool children (same age) in terms of anthropometry and fitness simultaneously, is a first step towards gaining knowledge of the potential threat that young children have in developing chronic diseases later in life. This can be considered a strength of this study.

In conclusion, our study provides data on anthropometry and fitness tests in low-income Chilean boys and girls preschool children. The prevalence of overweight and obesity was greater in girls than in boys, and the opposite occurred with the prevalence of obesity. Compared to normal-weight peers, overweight/obese boys and girls have a better performance in handgrip and their level in standing long jump and 20 m sprint may not be worse. Screening not only the anthropometric but also fitness characteristics may provide professionals an efficacy tool to design physical activity programmes.

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Conflict of interest

The authors declare that they have no conflict of interest.

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