Original Article

The relationship between physical activity, physical fitness and fatness in 3–6 years old boys and girls: a cross-sectional study

Guiomar Serrano-Gallén[1], Natalia M. Arias-Palencia[1], Sixto González-Víllora[1], Víctor Gil-López[1], Monserrat Solera-Martínez[2,3]

[1]Faculty of Education, University of Castilla-La Mancha, Cuenca, Spain; [2]Faculty of Nursing, University of Castilla-La Mancha, Cuenca, Spain; [3]Center for Socio-Sanitary Studies, University of Castilla-La Mancha, Cuenca, Spain

Contributions: (I) Conception and design: NM Arias-Palencia, G Serrano-Gallén; (II) Administrative support: NM Arias-Palencia; (III) Provision of study materials or patients: NM Arias-Palencia; (IV) Collection and assembly of data: G Serrano-Gallén, NM Arias-Palencia, V Gil-López; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Natalia M. Arias-Palencia. Faculty of Education, Universidad de Castilla la Mancha, Campus de Cuenca, Edificio Fray Luis de León, Camino Pozuelo, s/n, 16071, Cuenca, Spain. Email: natalia.arias@uclm.es.

Background: Physical activity (PA), fatness and fitness in children and teenagers have been associated with short and long-term health benefits. However, little research analyzing these variables focuses on the preschool education stage. Thus, the objective of this research is to study the relationship between PA, fatness and fitness in 3–6 years old boys and girls.

Methods: This cross-sectional study includes 150 boys and girls at age between 3 and 6 years. Fatness and fitness were assessed using a PREFIT (FITness testing in PREschool children) battery as well as the sit and reach test. PA levels were measured using accelerometers for 7 days.

Results: Higher PA levels were related to better fitness values. In addition, differences were found in the PA levels between boys and girls. However, PA subcomponents were not related to fatness. Furthermore, there were no significant differences in fitness tests between underweight, normal-weight and over-weight children, except in handgrip strength.

Conclusions: The few studies that have analyzed the relationship between fatness, fitness and PA in preschool have revealed controversial results. However, our study is in accordance with the majority of studies which prove that PA is associated with better fitness performances in preschool children. Since fitness is an important indicator of health, schools and parents should encourage children to practice more daily PA, especially girls, who are less active than boys. However, the discrepancy about the relationship between PA and fatness between the results of the different research highlights the necessity of carrying out further studies that analyze the relationship between these 3 variables separately in each age group (3, 4, 5 and 6 years). This is due to the fact that associations were stronger in older children rather than in younger children.

Keywords: Body composition; children; sex

Submitted Jan 23, 2022. Accepted for publication Apr 19, 2022.
doi: 10.21037/tp-22-30
View this article at: https://dx.doi.org/10.21037/tp-22-30

Introduction

Physical activity (PA) is currently being currently widely studied. PA in children has been associated with short and long-term health benefits (1,2). Regular PA improves fitness levels in children and teenagers (3). PA also prevents obesity (4). Nowadays, urbanization processes, environmental pollution, security considerations, and changes in family structure (5) have decreased PA levels. Furthermore, Aranceta-Bartrina, Gianzo-Citores and Pérez-Rodrigo (6) have shown that the prevalence of being overweight in Spanish children aged between 3 and 8 is 40%, while that of obesity is 16%. This is aggravated by the importance that this stage demonstrates for the creation of healthy habits that are maintained throughout adulthood (7).

Most of the research has shown that fitness is a powerful health indicator in children (2,8,9,10). In addition, many studies have shown a direct relationship between PA, especially moderate-to-vigorous PA (MVPA), and fitness (5,11,12). Some research has revealed that higher-intensity PA levels (MVPA and vigorous PA) relate more to an increased level of fitness and a decreased fatness level than light PA (11).

Moreover, the term fatness generates controversy among different researchers as to whether it should be included within physical fitness as an additional component or whether it should be treated individually as a health outcome itself (9). For this research it will be treated as a separate element of physical fitness. Over-weight and obesity in childhood are linked to increased cardiometabolic risk and to a higher risk of becoming obese adults. In addition, they are also associated with a greater likelihood of contracting future diseases, such as type 2 diabetes mellitus, cardiovascular disease and some types of cancer (6). Studies have shown that fatness correlates inversely with PA levels (8,13). However, the results of the different research that has studied fatness and PA in preschool children are inconclusive. Hence, there is no concordance about the age at which fatness begins in order to be related to PA (14).

Most of the research that has studied fatness, fitness and PA has been conducted in primary and secondary education stages (6–18 years) (4,15), but few studies have been developed in the preschool education stage (3–6 years) (9,16,17). For this reason, the objective of this research is to study the relationship between PA, fatness and fitness in 3–6 years old boys and girls. We present the following article in accordance with the STROBE reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-22-30/rc).

Methods

Participants

This cross-sectional research included 230 children (109 boys and 121 girls) aged 3 to 6 with a mean age of 4.92±0.84 from 3 urban and public schools in Cuenca, Spain. There were 39 participants who were 3 years old, while 79 children were 4 years old, 88 students were 5 years old and 24 children were 6 years old. Of the 230 participants included in this study, only 150 participants (65.22%) who had data that met the PA inclusion criteria were included in the statistical analyses. The children included in this analysis did not differ in age or sex from the whole sample of children participating in the study.

The participants of the 3 schools included in the study possess similar socioeconomic characteristics. The majority of them are residents of Cuenca, a small city with approximately 50,000 inhabitants. Their families maintain a low-to-middle economic level. However, in one of the schools, most families are upper middle class, while in the other two schools there is a higher proportion of lower-middle to lower-class families.

Ethical statement

Firstly, this study was approved (No. 2021/PI0721) by the researchers' health and research department ethics committee from Cuenca, "Comité Ético de Investigación del Área de Salud de Cuenca". In addition, written consent from the schools' Board of Governors and the students' parents was obtained to conduct the study. The directors of the different schools were contacted to explain what the research consisted of. The researchers assured them of the anonymity and confidentiality of the data obtained and that no student would suffer any type of harm. Parents could refuse to allow their children to participate in the research or in certain parts of it. In addition, teachers were interviewed to collect information about the health history of the participants, in order to find out whether any of them had medical problems that could affect the measures. Furthermore, all the researchers were specifically trained to carry out the study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Procedures

Data was collected between February and June 2019. Children of the same age were tested on the same day. A newsletter was sent to the parents the day before data was taken to remind them that the next day children had to wear sports clothes.

Anthropometry measures

The tests included examined weight, height, fat mass percentage, triceps skinfold, waist circumference and waist-to-height ratio. Fat mass percentage and weight were measured twice with an electronic scale (SECA Model 861; Vogel and Halke, Hamburg, Germany, precision =100 g, range, 0–150 kg); students wore light clothing and no shoes. Height was measured twice using a wall-mounted stadiometer (Seca Model 222; Vogel and Halke, Hamburg, Germany, precision =0.1 cm, range, 6–230 cm); children stood barefoot and straight against the wall to align their spine with the instrument. The head was positioned with the chin parallel to the floor.

The mean of the 2 measurements of weight and height was used to calculate students' body mass index (BMI): weight in kilograms divided by the square of the height in meters (BMI: kg/m^2). Cole and Lobstein's (18) age-adjusted BMI cut-off points were used to define underweight, normal-weight, overweight and obese children. The participants were placed into 2 groups to analyze the group differences between means. One group was normal weight and included underweight and normal-weight subjects, and the other group was overweight and included overweight and obese children. Waist circumference was measured twice at the midpoint between the last rib and the iliac crest using flexible tape. Triceps skinfold was measured 3 times at the triceps on the nondominant side of the body halfway between the acromion process and the olecranon process using a Holtain Ltd. caliber (0.2 mm accuracy and consistent 10 g/mm^2 pressure between valves). Finally, the average of the 2 measurements of waist circumference and height was used to calculate students' waist-to-height ratio: waist circumference in centimeters divided by height in centimeters.

Physical fitness measures

A PREFIT (FITness testing in PREschool children) battery, designed and validated for preschool children (9,19), was used to measure physical fitness. Moreover, the sit and reach test was used to measure flexibility, a health-related fitness component (5) that is not measured using a PREFIT battery.

Handgrip strength and standing long jump tests were used to assess muscular strength. Handgrip strength was measured with a manual dynamometer (TKK 5001, Grip-A, Takei, Tokyo, Japan). For the standing long jump, the child jumped horizontally to achieve maximum distance, with the best of 3 attempts being recorded in centimeters. Speed-agility was assessed with the 4×10 m shuttle run test of speed of movement, agility and coordination (19). An evaluator drew 2 parallel lines 10 m apart on the floor. Two examiners were positioned behind the lines. The participants ran 4×10 m (back and forth) as fast as possible, crossing each line with both feet. Every time children crossed any of the lines, they would touch the examiner's hand. The stopwatch was stopped when the children crossed the end line with one foot. The test was performed twice with at least 5 minutes of rest between attempts and the best score was recorded in seconds, down to hundredths.

Finally, the PREFIT 20 m shuttle run test was used to assess cardiorespiratory fitness (19). For this test, 10 lanes of 20 m were created. In addition, the warning zone where children were located when the beep sounded was marked at 3 m. The test was led by a recording that indicated, with beeps, the speed at which they should run. An examiner stood in one of the lanes and ran alongside the students during the test to help them adjust their velocity to that of the recording. The initial speed of the signal was 6.5 km/h and it increased by 0.5 km/h/min. The children had to reach the 20 m line before changing direction whether they were inside or outside the warning zone, even if the signal sounded. If a child was not in the designated 3 m zone when the signal sounded, a warning was given, and if this happened again for the second consecutive time, the test finished. The test also ended when the students were unable to continue due to exhaustion. The test was performed once and the total number of completed 20 m laps was recorded.

In addition, the sit and reach test was used to assess flexibility (20). The children sat barefoot with their legs stretched out in front of them and the soles of their feet completely touching the drawer wall. One hand was placed on top of the other and without bending their knees, the students slowly and progressively, did a deep trunk flexion. Three attempts were made that were registered in cm and mm and then the best attempt was documented.

Measurement of PA

The children wore a triaxial accelerometer (Actigraph GT3X model) for seven consecutive days to measure PA. Accelerometers are worn on the right side of the waist attached with an elastic band. A sheet with information related to the accelerometers was sent to the parents to explain that these devices must not get wet; thus, to bathe the children or to go to the pool, parents had to take the device off, and when the activity was over, the device had to be readjusted with the elastic band on the right side of the waist. The information from each accelerometer was programmed in 100 Hz and exported in one-second epochs. The cut-off values of Pate *et al.* (21) were used to define the intensity of PA and, therefore, quantify the average time in each intensity: sedentary time ≤800 counts per min (cpm), light PA =800–1,679 cpm, moderate PA = 1,680–3,367, vigorous PA ≥3,368, and MVPA was calculated as the sum of moderate and vigorous PA. In addition, the total daily PA was calculated as the sum of light, moderate and vigorous PA.

Accelerometer data was processed using the software Actilife V. 6.13.4 to provide values for total daily and hourly cpm. The following inclusion criteria was used: wearing the accelerometer for a minimum of three days, including at least two weekdays and one weekend day for a minimum of ten registered hours per day (22), excluding 20-min intervals of continuous "zero" activity with allowance for 1–2 min of counts between 0 and 100 (23). The sleep period was also ignored as the study only analyzed the performance level of PA during the day. Children who did not follow the requirements were excluded from the analysis.

Statistical analyses

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 25.0 for Windows (IBM SPSS Statistics, Armonk, NY, USA). Descriptive statistics were presented as mean ± standard deviations. Descriptive data of the PA subcomponents were adjusted to the valid wearing time per day using minutes (5). A covariance analysis was used in order to calculate the mean of the PA subcomponents. The Kolmogorov-Smirnov test was used to check for normality before the analysis. All variables presented normal distribution. An independent *t*-test was used to analyze sex differences between means. An analysis of variance was used to analyze average differences between underweight, normal-weight and overweight/obese children. Separated multiple linear regression models were employed to examine the associations of each of the dependent fatness variables (% body fat, waist circumference, triceps skinfold and waist-to-height ratio) with each of the independent fitness variables (20 m shuttle run, 4×10 m shuttle run, standing long jump, sit and reach, handgrip strength) and PA subcomponent variables (sedentary, light, moderate, vigorous, MVPA, total PA and counts per minute). Moreover, the associations between each of the dependent fitness variables (20 m shuttle run, 4×10 m shuttle run, standing long jump, sit and reach, handgrip strength) and each of the independent PA subcomponent variables (sedentary, light, moderate, vigorous, MVPA, total PA and counts per minute) were further examined. Two regression models were used: the unadjusted model and the model adjusted for the age and sex of the child. Standardized β coefficients were used. The variance inflation factors between variables were less than five, suggesting that multicollinearity was not a problem in the models (24). Significance was set at 5%. As a result, all P values less than 0.05 were treated as significant.

Results

Data on participants compared by sex is presented in *Table 1*. Boys had a higher significant performance ($P<0.05$) in the 20 m shuttle run tests, while girls outperformed boys in the sit and reach test. However, fatness values were similar in both sexes, except in triceps skinfold, in which girls had a higher mean. Finally, boys had better values ($P<0.05$) in some PA subcomponents (sedentary time, moderate PA, MVPA and cpm).

Participants' descriptive data according to weight status is shown in *Table 2*. Overweight/obese children had higher significant values ($P<0.05$) in height, weight, fat mass percentage, waist circumference, triceps skinfold, waist-to-height ratio and handgrip strength than underweight and normal-weight children. Furthermore, fitness test performances and PA subcomponent values were similar in underweight, normal-weight and overweight/obese children.

The associations among the different variables of fatness with each fitness test and PA subcomponents are demonstrated in *Table 3*. The increase in the percentage of fat mass was related to decreased results in the sit and reach test and cpm in the unadjusted model and the sit and reach and 4×10 m shuttle run tests in the adjusted model.

Waist circumference was positively related to handgrip strength and time spent in a sedentary position in the unadjusted model. Moreover, a higher triceps skinfold was related to lower counts per minute in the unadjusted model. However, these associations were no longer significant after adjusting for age and sex.

Finally, waist-to-height ratio was related to decreased results in handgrip strength, standing long jump, 4×10 m shuttle run and 20 m shuttle run in the unadjusted model. In addition, the waist-to-height ratio was negatively associated with vigorous PA and cpm in both models.

The associations between physical fitness tests and PA subcomponents are demonstrated in *Table 4*. Time spent in a sedentary position was related to decreased results in the standing long jump and 4×10 m shuttle run test in the adjusted model. Light and moderate PA was associated

Table 1 Descriptive data of the participants comparing by sex

	Boys (n=70)	Girls (n=80)	Whole sample (n=150)
Height (cm)	108.77±7.00	110.24±8.08	109.55±7.61
Weight (kg)	18.55±3.15	19.47±4.13	19.04±3.72
Fat mass (%)	20.69±3.17	21.86±4.83	21.32±4.16
Waist circumference (cm)	53.35±3.97	54.44±4.55	53.93±4.31
Triceps skinfold (mm)	10.55±2.92	11.76±3.62*	11.21±3.36
Waist-to-height ratio	0.49±0.32	0.49±0.35	0.49±0.03
Handgrip strength (kg)	7.08±1.71	7.18±2.01	7.13±1.86
Standing long jump (cm)	91.65±25.40	87.19±27.21	89.27±26.38
Sit and reach (cm)	27.20±3.88	29.04±3.72*	28.18±3.89
4×10 m shuttle run (s)	16.24±1.87	16.74±2.26	16.50±2.09
20 m shuttle run (laps)	36.59±20.66*	30.16±16.90	33.16±18.96
Sedentary time per day (min) †	587.38±47.34*	600.28±35.22	594.26±41.68
Light PA per day (min) †	57.12±12.11	54.99±8.07	55.98±10.17
Moderate PA per day (min) †	60.45±11.16*	57.55±9.66	58.90±10.45
Vigorous PA per day (min) †	51.67±14.69	48.93±11.22	50.21±12.98
MVPA per day (min) †	112.11±20.82*	106.49±19.11	109.11±20.06
Counts per minute (counts) †	1,615.69±240.80*	1,530.33±222.33	1,570.17±234.28

Values are means ± standard deviations. *, better significant performance (P<0.05); †, adjusted to the valid wearing time per day. PA, physical activity; MVPA, moderate-to-vigorous physical activity.

with a better performance in the 4×10 m shuttle run test in both models. Vigorous PA, MVPA, total PA and cpm were associated with improved values in the standing long jump and 4×10 m shuttle run in both models. In addition, MVPA and cpm were positively associated with the 20 m shuttle run in the unadjusted model.

Discussion

This research aimed to study the relationship between PA, fatness and fitness in 3–6 years old boys and girls. The major findings were: (I) differences in the PA levels between boys and girls were detected; (II) no significant differences in fitness tests between underweight, normal-weight and overweight/obese children were found, except in handgrip strength, in which overweight/obese children performed better; (III) fatness was not related to PA subcomponents; (IV) higher PA levels were linked to better physical fitness values.

Higher PA levels, especially MVPA, vigorous PA and total PA, were associated with an enhanced performance in physical fitness tests (standing long jump and 4×10 m shuttle run). This finding is in accordance with the research of Carson *et al.* (12), Fang *et al.* (5) and Riso *et al.* (11). However, according to Fang *et al.* (5), associations among PA levels, handgrip strength and the sit and reach tests were not found. Nevertheless, Riso *et al.* (11) found significant associations (P<0.05) between MVPA and handgrip strength. The difference might be due to the age of the participants (6–7 years).

Thus, our results confirmed that PA is associated with better physical fitness, which is a powerful health indicator for children. However, O'Dwyer *et al.* (25) and Nielsen-Rodríguez, Romance and Dobado-Castañeda (26) indicated that time spent in preschool is related to decreased PA. Subsequently, schools should promote an active lifestyle and increase the time that students spend performing MVPA in order to help children meet daily PA recommendations and obtain the short- and long-term health benefits of PA. In addition, sedentary behaviour after school has increased (5).

Table 2 Descriptive data of the participants according to weight status†

	Underweight (n=20)	Normal weight (n=107)	Overweight/Obese (n=23)
Age (years)	4.73±0.99	5.06±0.78	5.22±0.84
Height (cm)	104.65±8.78	109.56±6.92	113.80±7.34*
Weight (kg)	15.06±2.53	18.65±2.54	24.34±3.56*
Body fat (%)	17.27±2.07	20.60±2.73	28.15±3.43*
Waist circumference (cm)	49.04±2.88	53.37±2.57	60.82±3.75*
Triceps skinfold (mm)	8.27±1.28	10.62±2.25	16.49±3.41*
Waist-to-height ratio	0.47±0.03	0.49±0.03	0.54±0.04*
Handgrip strength (kg)	7.02±1.98	6.95±1.67	8.18±2.46*
Standing long jump (cm)	78.74±35.48	81.66±24.69	86.96±24.19
Sit and reach (cm)	28.23±4.07	28.47±3.64	26.79±4.68
4×10 m shuttle run (s)	16.96±2.22	16.40±2.15	16.57±1.67
20 m shuttle run (laps)	29.45±18.70	34.27±19.21	31.26±18.22
Sedentary time per day (min) ‡	592.08±39.39	593.59±41.38	599.26±46.25
Light PA per day (min) ‡	55.78±8.07	55.90±11.02	56.55±7.72
Moderate PA per day (min) ‡	57.71±10.92	58.87±10.63	60.10±9.44
Vigorous PA per day (min) ‡	50.55±14.75	50.36±13.31	49.20±9.92
MVPA per day (min) ‡	108.26±24.40	109.23±19.84	109.31±17.70
Counts per minute (counts)‡	1,593.90±294.68	1,573.05±232.51	1,536.12±185.73

Values are means ± standard deviations. †, defined by the Cole TJ, Lobstein T. Extended international (IOTF) body mass index cutoffs for underweight, overweight and obesity; *, significantly higher values ($P<0.05$); ‡, adjusted to the valid wearing time per day. PA, physical activity; MVPA, moderate-to-vigorous physical activity.

Xu *et al.* (27) demonstrated that parental levels of PA have an effect on the corresponding levels of their preschool children. Thus, parents should encourage their children to practice more exercise after school. Motor literacy should be practiced and/or children should be enrolled in extracurricular activities and sports clubs. Therefore, schools and parents should provide an ideal environment for preschool children to practice PA with different initiatives such as active breaks or active commuting to school.

However, differences have been found in the PA levels related to sex. Boys demonstrated better values in some PA subcomponents (sedentary time, moderate PA, MVPA and cpm). This finding is in accordance with Xu *et al.*'s (27) and Nilsen *et al.*'s (28) results. Xu *et al.* (27) showed that the mean sedentary value for girls was higher than that of boys. Nilsen *et al.* (28) revealed that boys were consistently more active and less sedentary than girls. Since PA improves physical fitness, adults should encourage girls to increase the amount of time that they spend performing PA, especially MVPA and Vigorous PA.

Regarding weight status, our results have demonstrated that fatness values were not significantly related to PA levels in preschool children. These results concur with those found by Carson *et al.*'s (12) review, which observed a lot of null, unfavorable, and inconclusive associations between PA and fatness. The conclusion in this research revealed that only the waist-to-height ratio is related to some PA subcomponents in the adjusted model. However, we cannot be certain of the significance of this association as we have found few studies that analyze the relationship between these variables in preschool children (29). Hence, Mota *et al.* (29) studied the association between sedentary behavior time and waist-to height ratio. Their results revealed that these two variables are related in boys, but not in girls. However, our research was unable to find any association between them. Therefore, this aspect should be

Table 3 The relationship between physical fitness and physical activity with body composition values

Independent variable	Dependent variable											
	% Body fat			Waist circumference			Triceps skinfold			Waist-to-height ratio		
	r^2	β	P value	r^2	β	P value	r^2	β	P value	r^2	β	P value
Models without adjustment												
Handgrip strength	0.009	0.095	0.309	0.036	0.189	0.042*	0.003	0.055	0.555	0.058	–0.241	0.009*
Standing long jump	0.001	–0.029	0.723	0.018	0.134	0.104	0.006	–0.079	0.341	0.065	–0.255	0.002*
Sit and reach	0.027	–0.182	0.026*	0.006	–0.080	0.329	0.008	–0.091	0.269	0.013	–0.113	0.170
4×10 m shuttle run†	0.025	0.158	0.053	0.022	–0.149	0.070	0.009	0.096	0.241	0.132	0.364	<0.001*
20 m shuttle run	0.012	–0.111	0.175	0.003	0.051	0.536	0.004	–0.066	0.421	0.086	–0.293	<0.001*
Sedentary time per day	0.003	0.055	0.502	0.032	0.180	0.028*	0.005	0.072	0.381	0.007	–0.084	0.307
Light PA per day	0.006	–0.080	0.333	0.000	0.005	0.949	0.007	–0.085	0.299	0.004	0.060	0.466
Moderate PA per day	0.001	–0.034	0.675	0.002	0.045	0.586	0.005	–0.071	0.391	0.001	–0.029	0.728
Vigorous PA per day	0.013	–0.112	0.171	0.001	–0.022	0.785	0.014	–0.119	0.148	0.033	–0.181	0.026*
MVPA per day	0.008	–0.091	0.270	0.000	0.009	0.915	0.013	–0.114	0.166	0.018	–0.132	0.106
Total PA per day	0.010	–0.100	0.225	0.000	0.009	0.915	0.014	–0.119	0.146	0.006	–0.077	0.346
Counts per minute	0.029	–0.171	0.037*	0.008	–0.090	0.272	0.026	–0.160	0.050*	0.040	–0.200	0.014*
Models adjustment for age and sex												
Handgrip strength	0.299	0.064	0.423	0.298	0.056	0.495	0.296	0.037	0.647	0.299	–0.067	0.426
Standing long jump	0.249	–0.026	0.723	0.249	–0.013	0.869	0.255	–0.081	0.273	0.252	–0.057	0.473
Sit and reach	0.103	–0.219	0.006*	0.069	–0.119	0.166	0.075	–0.138	0.091	0.077	–0.160	0.069
4×10 m shuttle run†	0.418	0.156	0.016*	0.396	0.041	0.546	0.404	0.100	0.124	0.407	0.123	0.082
20 m shuttle run	0.273	–0.098	0.169	0.272	–0.097	0.201	0.267	–0.055	0.448	0.272	–0.100	0.199
Sedentary time per day	0.087	0.030	0.712	0.093	0.091	0.283	0.087	0.036	0.655	0.086	0.013	0.878
Light PA per day	0.015	–0.066	0.424	0.011	0.018	0.834	0.016	–0.069	0.411	0.017	0.083	0.360
Moderate PA per day	0.020	–0.016	0.848	0.023	0.060	0.489	0.022	–0.048	0.565	0.020	–0.012	0.895
Vigorous PA per day	0.023	–0.100	0.226	0.014	–0.027	0.758	0.024	–0.105	0.210	0.043	–0.191	0.034*
MVPA per day	0.027	–0.073	0.376	0.022	0.014	0.873	0.030	–0.093	0.265	0.036	–0.130	0.150
Total PA per day	0.029	–0.081	0.325	0.023	0.018	0.839	0.032	–0.097	0.243	0.027	–0.066	0.461
Counts per minute	0.055	–0.148	0.070	0.039	–0.079	0.366	0.050	–0.132	0.111	0.076	–0.228	0.010*

†, lower values indicate better performance; *, significantly higher values (P<0.05). PA, physical activity; MVPA, moderate-to-vigorous physical activity.

studied more extensively in the future.

Moreover, fatness values were not significantly related to physical fitness tests in preschool children. There are few significant associations (P<0.05) between fatness subcomponents and physical fitness tests in the unadjusted model. However, these associations were no longer significant after adjusting for age and sex, except the inversely association between the percentage of body fat with the sit and reach and 4×10 m shuttle run tests. This finding is in accordance with Kim *et al.*'s (30) study, which was unable to detect relationships between met PA recommendations and fatness.

Therefore, obesity doesn't seem to be related to PA and physical fitness in preschool children. There is no relation

Table 4 The relationship between physical fitness values and different PA subcomponents

Independent variable	Dependent variable														
	Handgrip strength			Standing long jump			Sit and reach			4×10 m shuttle run[†]			20 m shuttle run		
	r^2	β	P value	r^2	β	P value	r^2	β	P value	r^2	β	P value	r^2	β	P value
Models without adjustment															
Sedentary time per day	0.002	0.040	0.666	0.001	−0.028	0.740	0.015	0.122	0.137	0.000	0.022	0.790	0.000	0.005	0.947
Light PA per day	0.005	−0.074	0.429	0.004	0.065	0.429	0.008	0.087	0.288	0.032	−0.179	0.028*	0.006	0.080	0.329
Moderate PA per day	0.001	0.023	0.810	0.019	0.138	0.096	0.001	0.024	0.775	0.058	−0.242	0.003*	0.016	0.126	0.125
Vigorous PA per day	0.000	0.017	0.860	0.048	0.220	0.007*	0.000	−0.007	0.933	0.048	−0.220	0.007*	0.024	0.154	0.060
MVPA per day	0.001	0.023	0.802	0.046	0.214	0.009*	0.000	0.008	0.925	0.072	−0.268	0.001*	0.027	0.165	0.044*
Total PA per day	0.000	−0.014	0.884	0.035	0.188	0.022*	0.002	0.040	0.630	0.074	−0.273	0.001*	0.024	0.156	0.056
Counts per minute	0.001	0.030	0.749	0.073	0.270	0.001*	0.002	0.041	0.616	0.080	−0.284	<0.001*	0.026	0.161	0.050*
Models adjustment for age and sex															
Sedentary time per day	0.087	−0.137	0.202	0.111	−0.182	0.047*	0.094	0.095	0.242	0.126	0.258	0.010*	0.096	−0.121	0.191
Light PA per day	0.024	−0.049	0.661	0.014	0.072	0.453	0.024	0.119	0.160	0.055	−0.268	0.010*	0.016	0.080	0.403
Moderate PA per day	0.042	0.118	0.284	0.037	0.149	0.118	0.023	0.060	0.476	0.091	−0.343	0.001*	0.031	0.120	0.207
Vigorous PA per day	0.020	0.103	0.355	0.060	0.257	0.007*	0.014	0.020	0.814	0.066	−0.296	0.005*	0.031	0.155	0.105
MVPA per day	0.041	0.134	0.225	0.064	0.243	0.010*	0.024	0.044	0.586	0.105	−0.370	<0.001*	0.041	0.163	0.086
Total PA per day	0.040	0.080	0.466	0.055	0.213	0.024*	0.029	0.080	0.345	0.113	−0.385	<0.001*	0.041	0.155	0.103
Counts per minute	0.065	0.179	0.102	0.118	0.340	<0.001*	0.041	0.089	0.285	0.144	−0.427	<0.001*	0.055	0.173	0.067

*, significantly higher values (P<0.05); [†], lower values indicate better performance. PA, physical activity; MVPA, moderate-to-physical activity.

between the age at which fatness begins in order to be related to PA (14).

Nevertheless, this research has some limitations. Firstly, the sample size was not very big, especially the overweight/obese population (n=23). As a result, we were unable to separate overweight and obese children into different groups. This could influence the significant differences that were found as Niederer *et al.* (31) observed associations between normal-weight and obese children that were not found in overweight participants. In addition, many children did not meet the inclusion criteria. Consequently, associations could be influenced by the relatively small final sample (n=150). Another limitation was that a cross-sectional design was used, and as a result conclusions could not be drawn on the causality and direction of associations found (11,32). Moreover, the research did not analyze certain variables that could be influential, such as socioeconomic status or participation in sports clubs (31,32). Regarding fatness, fat-free mass was not studied, which Riso *et al.* (11) found was associated with all physical fitness and PA levels. Given that it is an important value, it should have been analyzed. However, waist circumference and triceps skinfold were included, which few research has studied. Subsequently, our study revealed new information about the relationship of these fatness variables with fitness and PA levels.

The strength of this study highlights the use of objective measurements. PA was measured by accelerometer and physical fitness by a PREFIT battery, which is validated for preschool children (9). In addition, this study included certain variables that few research has studied, including flexibility, waist circumference and cpm. Moreover, we used a model that was adjusted to the age and sex of the participants to analyze data. Differences among the variables in the unadjusted model usually disappeared in the adjusted model because these variables are influenced by age and sex. Therefore, the results showed the real relationship between fatness, fitness, and PA regardless of age or sex. Finally, the sample included 3-year-old children, who were excluded in the research that previously studied preschool children's health.

Conclusions

Higher PA levels are related to better values of physical fitness, which is an important health indicator in children. Therefore, to improve the health of preschool children, an active lifestyle must be encouraged.

However, daily PA performed does not influence fatness in preschool children. Nevertheless, some experts have proposed that the relationship between PA, fitness and fatness increases with the age of the participants (17). The discrepancy between the results of the different research makes it necessary to carry out more studies that analyze the relationship between these three variables separately within each age group (3, 4, 5 and 6 years) as associations were stronger in older children than in younger children (14). Therefore, there are differences in the results concerning the studies whose sample only includes children from the last year of preschool. Knowing this, it would be interesting to study the evolution of the relationship between these three variables from year to year to see if age explains the discrepancies found.

Likewise, it would be interesting to examine the relationship of these three variables with other sociocultural ones (urban or rural environment, socioeconomic level, level of education of the parents, type of family, etc.) to check whether they also affect the relationship.

Acknowledgments

The authors would like to thank the schools, the children and the parents of the children who participated in the study for allowing us to collect the data, and the examiners who helped collect it.
Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tp.amegroups.com/article/view/10.21037/tp-22-30/rc

Data Sharing Statement: Available at https://tp.amegroups.com/article/view/10.21037/tp-22-30/dss

Peer Review File: Available at https://tp.amegroups.com/article/view/10.21037/tp-22-30/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tp.amegroups.com/article/view/10.21037/tp-22-30/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by The health and research department from Cuenca, "CEI del Área de Salud de Cuenca" (No. 2021/PI0721) and informed consent was taken from all participants' parents.

References

1. Gibson-Moore H. UK Chief Medical Officers' physical activity guidelines 2019: What's new and how can we get people more active? Nutr Bull 2019;44:320-28.
2. Henriksson P, Leppänen MH, Henriksson H, et al. Physical fitness in relation to later body composition in pre-school children. J Sci Med Sport 2019;22:574-79.
3. Soler-Lanagrán A, Castañeda-Vázquez C. Sedentary lifestyle and health risks in children. A systematic review. J Sport Health Res 2017;9:187-98.
4. Parikh T, Stratton G. Influence of intensity of physical activity on adiposity and cardiorespiratory fitness in 5-18 year olds. Sports Med 2011;41:477-88.
5. Fang H, Quan M, Zhou T, et al. Relationship between Physical Activity and Physical Fitness in Preschool Children: A Cross-Sectional Study. Biomed Res Int 2017;2017:9314026.
6. Aranceta-Bartrina J, Gianzo-Citores M, Pérez-Rodrigo C. Prevalence of overweight, obesity and abdominal obesity in the Spanish population aged 3 to 24 years. The ENPE study. Rev Esp Cardiol (Engl Ed) 2020;73:290-9.
7. Haga M, Gísladóttír T, Sigmundsson H. The relationship between motor competence and physical fitness is weaker in the 15–16 yr. adolescent age group than in younger age groups

(4–5 yr. and 11–12 yr.). Percept Mot Skills 2015;121:900-12.
8. Leppänen MH, Henriksson P, Henriksson H, et al. Physical Activity Level Using Doubly-Labeled Water in Relation to Body Composition and Physical Fitness in Preschoolers. Medicina (Kaunas) 2019;55:2.
9. Ortega FB, Cadenas-Sánchez C, Sánchez-Delgado G, et al. Systematic review and proposal of a field-based physical fitness-test battery in preschool children: the PREFIT battery. Sports Med 2015;45:533-55.
10. Redondo-Tébar A, Ruíz-Hermosa A, Martínez-Vizcaíno V, et al. Associations between health-related quality of life and physical fitness in 4-7-year-old Spanish children: the MOVIKIDS study. Qual Life Res 2019;28:1751-9.
11. Riso EM, Toplaan L, Viira P, et al. Physical fitness and physical activity of 6-7-year-old children according to weight status and sports participation. PLoS One 2019;14:e0218901.
12. Carson V, Lee EY, Hewitt L, et al. Systematic review of the relationships between physical activity and health indicators in the early years (0-4 years). BMC Public Health 2017;17:854.
13. iersma R, Haverkamp BF, van Beek JH, et al. Unravelling the association between accelerometer-derived physical activity and adiposity among preschool children: A systematic review and meta-analyses. Obes Rev 2020;21:e12936.
14. Aadland E, Holmøy OK, Nilsen AKO. The multivariate physical activity signature associated with body mass index in young children. Prev Med 2021;145:106437.
15. Estevan I, García-Massó X, Molina J, et al. Identifying profiles of children at risk of being less physically active: an exploratory study using a self-organised map approach for motor competence. J Sports Sci 2019;37:1356-64.
16. Cadenas-Sanchez C, Intemann T, Labayen I, et al. Physical fitness reference standards for preschool children: The PREFIT project. J Sci Med Sport 2019;22:430-7.
17. Henriksson P, Cadenas-Sanchez C, Leppänen MH, et al. Associations of Fat Mass and Fat-Free Mass with Physical Fitness in 4-Year-Old Children: Results from the MINISTOP Trial. Nutrients 2016;8:473.
18. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatr Obes 2012;7:284-94.
19. Cadenas-Sanchez C, Martinez-Tellez B, Sanchez-Delgado G, et al. Assessing physical fitness in preschool children: Feasibility, reliability and practical recommendations for the PREFIT battery. J Sci Med Sport 2016;19:910-5.
20. Ayán Pérez C, Álvarez Pérez S, González Baamonde S, et al. Influence of the Box Dimensions on the Reliability and Validity of the Sit and Reach in Preschoolers. J Strength Cond Res2020;34:2683-92.
21. Pate RR, Almeida MJ, McIver KL, et al. Validation and calibration of an accelerometer in preschool children. Obesity (Silver Spring) 2006;14:2000-6.
22. Hinkley T, O'Connell E, Okely AD, et al. Assessing volume of accelerometry data for reliability in preschool children. Med Sci Sports Exerc 2012;44:2436-41.
23. Carson V, Rahman AA, Wiebe SA. Associations of subjectively and objectively measured sedentary behavior and physical activity with cognitive development in the early years. Ment Health Phys Act 2017;13:1-8.
24. Marill KA. Advanced statistics: linear regression, part I: simple linear regression. Acad Emerg Med 2004;11:87-93.
25. O'Dwyer M, Fairclough SJ, Ridgers ND, et al. Patterns of objectively measured moderate-to-vigorous physical activity in preschool children. J Phys Act Health 2014;11:1233-8.
26. Nielsen-Rodríguez A, Romance R, Dobado-Castañeda JC. Teaching Methodologies and School Organization in Early Childhood Education and Its Association with Physical Activity. Int J Environ Res Public Health 2021;18:3836.
27. Xu C, Quan M, Zhang H, et al. Impact of parents' physical activity on preschool children's physical activity: a cross-sectional study. PeerJ 2018;6:e4405.
28. Nilsen AKO, Anderssen SA, Ylvisaaker E, et al. Physical activity among Norwegian preschoolers varies by sex, age, and season. Scand J Med Sci Sports 2019;29:862-73.
29. Mota J, Silva Dos Santos S, Santos A, et al. Association between sedentary behavior time and waist-to-height ratio in preschool children. Am J Hum Biol 2016;28:746-8.
30. Kim TV, Pham TND, Nguyen CLD, et al. Prevalence of Physical Activity, Screen Time, and Sleep, and Associations with Adiposity and Motor Development among Preschool-Age Children in Vietnam: The SUNRISE Vietnam Pilot Study. Indian J Pediatr 2022;89:148-53.
31. Niederer I, Kriemler S, Zahner L, et al. BMI group-related differences in physical fitness and physical activity in preschool-age children: a cross-sectional analysis. Res Q Exerc Sport 2012;83:12-9.
32. Latorre Román PÁ, Mora López D, García Pinillos F. Feeding practices, physical activity, and fitness in Spanish preschoolers: influence of sociodemographic outcome measures. Arch Argent Pediatr 2016;114:441-7.

Cite this article as: Serrano-Gallén G, Arias-Palencia NM, González-Víllora S, Gil-López V, Solera-Martínez M. The relationship between physical activity, physical fitness and fatness in 3–6 years old boys and girls: a cross-sectional study. Transl Pediatr 2022;11(7):1095-1104. doi: 10.21037/tp-22-30