Adiposity, Physical Activity, and Physical Fitness Among Children From Aragón, Spain

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Abstract

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Objective: The main purpose of this study was to determine the relationship between physical activity (PA) levels and adiposity. The secondary purpose was to assess the effect of physical fitness and living area on adiposity.

Research Methods and Procedures: A cross-sectional study was carried out in a regional representative sample of 1068 children 7 to 12 years of age. Anthropometric and physical fitness values (including BMI, aerobic capacity, strength levels, velocity assessment, and flexibility) were measured in all children.

Results: The prevalence of being overweight and obese in the entire sample was 31% and 6%, respectively. No difference between urban and rural children was found. The proportion of boys who were classified as overweight and obese was similar in physically active and sedentary (non-physically active) groups. However, physically active girls tended to show lower obesity prevalence compared with their sedentary counterparts ($p = 0.06$). In girls, the sum of the 6 skinfolds thickness (SSF) measurements was lower in the physically active group when compared with the non-physically active group ($p < 0.05$); however, this effect was not observed in boys. Multiple regression analysis revealed that the level of physical activity (PA) had a significant effect on BMI and SSF in boys but not in girls, while maximal oxygen uptake (VO_{2max}) was significantly related to adiposity in both sexes.

Discussion: Regular participation in at least 2 hours per week of sports activities on top of the compulsory education program is associated with better physical fitness and lower whole body adiposity. In the children included in our study, among all physical fitness variables, VO_{2max} showed the strongest relationship with BMI and fat mass assessed by means of skinfold measurements.

Key words: body composition, childhood obesity, exercise, health education

Introduction

According to the National Statistics Institute (1), Aragón is the fourth largest region in Spain (~48,000 km^2) and had approximately 1.2 million inhabitants in 2001; approximately 20.5% of this population is composed of children under 16 years of age (2). The northeast part of Spain, where Aragón is located, is known to have the lowest obesity prevalence in children 2 to 24 years of age in all of the country (3). However, data from the latest epidemiological studies that include information from 1985 to 1995 showed a significant and striking increase in the mean BMI values and also in the prevalence of being overweight and/or obese among children 6 to 7 and 13 to 14 years of age (4). Our study was developed in 2000 and is the last regional representative study. Data included in the present investigation are an update of the available figures and will serve to verify the current tendencies in this population. Moreover, new and interesting information regarding physical activity (PA)[1] levels and physical fitness is incorporated, including aerobic capacity, strength levels, velocity, and flexibility assessments in all of the investigated children.

Another important issue is whether physical fitness and/or physical activity level are determining factors for the BMI and adiposity in boys and girls.

Therefore, the main purpose of this study was to determine the relationship between PA levels and adiposity. The

[1] Nonstandard abbreviations: PA, physical activity; SSF, 6 skinfolds thickness; VO_{2max}, maximal oxygen uptake; SFT, truncal subcutaneous fat.

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secondary purpose was to assess the effect of physical fitness and living area on adiposity.

Research Methods and Procedures

Subjects

A random sample of 1068 healthy white school children (7 to 12 years of age) was selected using a multistage, proportional-cluster sampling from a total of 64,116 school children in the region of Aragón, Spain (maximum error 2% with 95% confidence). In the first step, a proportionate cluster with schools at the primary sampling cluster was used. The different strata were selected according to the structure of the local school system, the geographic distribution of the three provinces that composed Aragón, and by gender. In the second step, full classes from each grade of the primary schools were selected and used as the smallest sampling units. Participation rate was higher than 90%.

The definition and meanings of urban and rural residence may vary across studies and countries depending on their national standards (5). In our study, urban or rural area was determined according to the number of inhabitants of the population area. The region of Aragón is characterized by having only one city with more than 50,000 inhabitants (Zaragoza), and five cities with more than 10,000 inhabitants; that is the reason why we considered 10,000 inhabitants as the cut-off value for urban location (6).

Experimental Design

Each child underwent a one-day testing session. During this session, anthropometric assessments and physical fitness tests (in the same order as suggested for the one-day protocol published elsewhere (7,8)) were carried out. In addition, all children answered a questionnaire providing information about personal data, sports participation (including the number of training hours per week and the kind of sport), and medical history (including the past injuries and medication). Both parents and children were informed about the aims and procedures of the study, as well as the possible risks and benefits. Children gave their verbal consent and written informed consent was obtained from their parents. None of the subjects was on medication at the time of the study. The study was performed in accordance with the Helsinki Declaration of 1975 with regards to the conduct of clinical research, being approved by the Ethical Committee of the University of Zaragoza.

Anthropometry and Definition of Overweight and Obese

Anthropometric measurements were obtained on each subject. Height was measured in the upright position to the nearest millimeter (KaWe, ASperg, Germany). Body mass was determined using a balance with a 100-g imprecision (Seca, Hamburg, Germany). Children were consider as overweight or obese based on BMI age-specific curves when their BMI was more than or equal to the international cut-off point corresponding to the centile curve that passes through either the BMI curve of 25 or 30 kg/m^2, respectively, at age 18 years (9).

All anthropometric measurements were performed by two experienced physicians according to the well-standardized procedures of the International Society for the Advancement in Kinanthropometry. Skinfold thickness was measured in triplicate at biceps, triceps, subscapular, suprailiac, abdominal, and medium calf sites with a Holtain skinfold caliper (Holtain Ltd, Crosswell, United Kingdom), as previously described (10). The median value of the three measurements was taken as final value. The sum of the 6 skinfolds thickness (SSF) measurements from the whole body and those from the trunk region (subscapular, suprailiac, abdominal) were also calculated.

PA Levels

Children were stratified depending on the level of PA performed, in addition to that carried out during the physical education compulsory sessions included in the Spanish academic curriculum. The curriculum includes 80 to 90 minutes per week of PA. Physically active children were considered those who, in addition to the academic curriculum, participated in extracurricular sport activities and competitions at least 2 hours per week, for at least 1 year before the start of the study.

Measurement of Physical Fitness

Physical fitness was determined using eight physical fitness tests included in the European physical fitness test.

Aerobic fitness. The maximal oxygen uptake (Vo_{2max}) was estimated using the results of a maximal multistage 20-m shuttle running test (11,12). Subjects were required to run back and forth on a 20-m course and be on the 20-m line at the same time a beep is emitted from a tape. The frequency of the sound signal increases in such a way that running speed starts at 8.5 km/h and is increased by 0.5 km/h each minute. When the subjects can no longer follow the pace, the time the subjects were able to run for was recorded and used to calculate Vo_{2max}. This test has shown to be valid and reliable for the prediction of the Vo_{2max} in children (11,12).

Running speed. A 10 $\times$ 5 shuttle running and turning test at maximum speed were completed for all subjects and used to assess velocity. Two parallel lines were drawn on the floor separated by 5 m. Both feet had to cross the line each time. The time needed to complete five cycles (back and fourth) was recorded as the final score. All children were motivated to run as fast as they could.

Speed of limb movement. Two rubber discs, each 20 cm in diameter, were fixed horizontally on a table. The center points of the discs were 80 cm apart (edges, therefore, 60 cm apart). Standing in front of the table, feet slightly apart and with the non-preferred hand fixed on a rectangular plate located in the middle of the two discs, children were asked to rapidly tap the 2 plates alternately with the preferred hand during 25 cycles. The best performance of two attempts was taken as the representative value of this test.

Flexibility. From a seated position, children had to place their feet flat against one prepared box with a slide ruler between their feet. They were to gradually push the ruler with hands stretched, without jerking, and bend their trunk trying to reach forward as far as possible, always keeping the knees straight. Fingers of both hands had to reach the same distance, and bouncing movements were not allowed. The test was done twice, and the better result counted as the score (in centimeters).

Dynamic force. To assess the leg extension explosive strength, the jumping performance was measured. Each subject did jumps for distance from a standing start. During the performance of the jumps, the subjects were asked to bend their knees with their arms in front of them, parallel to the ground, then swing both arms, push off vigorously and jump as far forward as possible, trying to land with their feet together and stay upright. The better of two attempts was taken as the result (given in centimeters).

Trunk strength was assessed with the maximum number of sit-ups achieved in half a minute. Children were seated on the floor, backs straight, hands clasped behind their neck, knees bent at 90° with heels and feet flat on the mat. They then lay down on their backs, shoulders touching the mat, and returned to the sitting position with their elbows out in front to touch their knees, keeping the hands clasped behind their neck the whole time. The total number of correctly performed complete sit-ups in 30 seconds was the score.

Isometric Strength

Handgrip. A calibrated hand dynamometer with adjustable grip was used (TKK 5101; Takei, Tokyo, Japan). Children were asked to hold the dynamometer in their preferred hand, at their side without touching the rest of the body, and squeeze it forcefully keeping the instrument held in line with the forearm during the duration of the test. Children were required to squeeze gradually and continuously for at least 2 seconds. The best result was the score recorded in kilograms.

Bent arm hang. Before starting the test, children were asked to stand under the bar, put their fingers on top, thumb underneath, and place hands, shoulder-width apart, on the bar with a forward grip. Instructors helped lift the children until their chin was above the bar. Then children had to hold the position as long as possible without resting their chin on the bar. The test ended when the eyes went below the bar. The time in tenths of a second was the score.

Statistical Analysis

Descriptive statistics were run on all variables. Group differences in body composition and fitness test variables were assessed using unpaired Student's *t* test. χ^2 test was applied to assess differences in the prevalence of overweight and obesity between groups. Pearson correlation analysis was applied to identify the relationship between physical fitness and body composition variables. Stepwise multiple regression was used to determine the best predictor of the BMI and the SFF among all physical fitness tests. Additionally, multiple general linear models with successive BMI and SSF as dependent variables were used to evaluate the independent effects of age, PA levels, living area, and cardiorespiratory fitness. SPSS package (SPSS, Inc., Chicago, IL) software was used for the statistical analysis. The significance level was set at $p \leq 0.05$, and data are represented as means ± standard deviation unless otherwise stated.

Results

Prevalence of Overweight and Obesity

Similar overweight prevalence was founded in boys (30%) and girls (33%) whereas significant differences were found in the corresponding obesity rates (5% vs. 8%, $p < 0.05$, boys and girls, respectively). Six hundred eighty one boys and girls were considered the physically active group, while the other 387 were considered non-physically active. When active (374 boys and 307 girls) and sedentary (184 boys and 203 girls) children were compared, physically active boys showed a trend toward a slightly higher overweight and obesity prevalence than the non-physically active boys (32% vs. 25% and 6% vs. 2%, both $p = 0.09$ to 0.10). Conversely, physically active girls had lower obesity rates than non-physically active girls (6% vs. 10%, $p < 0.05$). Children from the rural area showed similar overweight (32% vs. 26% and 34% vs. 30%, boys and girls, respectively) and obesity rates (4% vs. 6% and 8% vs. 7%, boys and girls, respectively) compared with their urban counterparts.

Anthropometry

Table 1 summarizes anthropometric data for all children of the study. Girls had comparable age, body mass, height, and BMI values between physically active and non-physically active groups. Physically active boys showed significantly higher values in body mass, height, and BMI (all $p \leq 0.05$). Calculated sum of the SSF showed a trend to lower values in the active group compared with the sedentary group ($p = 0.07$). Active girls had significantly lower subcutaneous fat masses than their sedentary counterparts in the whole body ($p < 0.05$) and at the trunk sites ($p = 0.07$).

PA Levels vs. Physical Fitness as Determining Factors for the BMI, SSF, and Truncal Subcutaneous Fat (SFT) Values

Apart from the plate tapping, the flexibility, and the bent arm hang tests, active boys attained better results in

Table 1. Subjects' age and anthropometric values

	Physically active group	Non-physically active group	Significance (*p*)
Boys			
Age (yrs)	9.7 ± 0.1	9.4 ± 0.1	0.06
Height (cm)	137.5 ± 0.6	135.4 ± 0.9	<0.05
Body mass (kg)	35.8 ± 0.6	33.5 ± 0.7	<0.05
BMI	18.5 ± 0.2	18.0 ± 0.2	0.05
Sum 6 skinfolds (mm)	62.9 ± 1.5	62.2 ± 2.3	NS
Sum trunk skinfolds (mm)	26.1 ± 0.9	25.8 ± 1.3	NS
Girls			
Age (years)	9.5 ± 0.1	9.4 ± 0.1	NS
Height (cm)	136.2 ± 0.7	136.0 ± 0.8	NS
Body mass (kg)	34.9 ± 0.6	35 ± 0.7	NS
BMI	18.5 ± 0.2	18.6 ± 0.2	NS
Sum 6 skinfolds (mm)	71.6 ± 1.4	76.6 ± 1.9	<0.05
Sum trunk skinfolds (mm)	29.2 ± 0.8	31.7 ± 1.1	0.07

NS, not significant. Unpaired *t* test, mean ± standard error.

all physical fitness test than their sedentary counterparts ($p < 0.05$). Active girls achieved better performance in every one of the physical tests except for the handgrip and the plate tapping tests, which were similar in both groups (Table 2).

The effect of interaction term gender by PA on BMI and adiposity was tested, and there was no significant effect ($p = 0.115$). Correlations between physical fitness variables and subcutaneous fat mass (truncal and whole body) were low ($r < 0.32$) except for the Vo_{2max} (r between 0.48 and 0.51, $p < 0.01$) and the bent arm hang test (r between 0.36 and 0.40, $p < 0.01$). The handgrip test showed the strongest correlation with the BMI values ($r = 0.48$, $p < 0.01$). Multiple regression analysis showed that, compared with the physical activity levels and the living area, cardiorespiratory fitness had the strongest relationship to the BMI, SSF, and SFT values (Table 3). No significant effect of the living area on adiposity and/or BMI was detected among the studied children.

Discussion

Prevalence of Overweight and Obesity in Children From Aragón

The low obesity prevalence (5% to 8%) found among the children of the study (7 to 12 years of age) differs from other national studies in this age group (11% to 22%, in children 6 to 13 years of age) (3,13), but one of these studies used the Spanish national reference values and not the international ones.

However, when children who are obese and overweight were considered together, these discrepancies disappeared, as similar values of overweight and obese children (30.8%) compared with some national studies (30.4% to 31.2%) (3,13) were found. Thus, even though obesity rates in this region are still lower in relation to the nationally representative study (especially in boys), the similarity in the overweight rates suggests that a slow but constant increase in the prevalence of being overweight among the children of Aragón is taking place.

In relation to gender, current national published data show that boys have almost double the prevalence of obesity of girls at the age of 6 to 9 years. However, and in agreement with data previously published in this region (6), our results indicate opposite findings, as illustrated by the significantly lower proportion of obese boys in relation to obese girls (4.7% vs. 7.7%, respectively).

Influence of the Residence Area on the Adiposity in Children

Data related to socio-demographic determinants on the trends of overweight and obesity prevalence in children is limited (14,15). Whether children live in an urban or rural environment could also affect the subsequent obesity status as a consequence of several factors that influence the total energy expenditure of the children (i.e., distance to school, proportion of physical activity facilities in the area, differences in parental habits, social inequalities, and others). Recent data published on youth 2 to 24 years of age reported

Table 2. Physical fitness results

	Physically active group	Non-physically active group	Significance (*p*)
Boys (*n*)	374	184	
VO_{2max} (mL/kg per min)	48.31 ± 4.36	46.59 ± 3.98	<0.05
Time in limb movement (s)	18.63 ± 4.74	18.90 ± 4.20	NS
Flexibility (cm)	16.58 ± 5.28	16.69 ± 5.42	NS
Jump performance (cm)	132.39 ± 25.91	127.17 ± 24.28	<0.05
Handgrip (kg)	17.00 ± 5.36	15.82 ± 4.80	<0.05
Sit-ups (n)	19.17 ± 5.94	17.34 ± 5.63	<0.05
Bent arm hang (s)	11.94 ± 11.50	10.70 ± 9.93	NS
Time in run speed test (s)	22.96 ± 2.54	23.47 ± 2.25	<0.05
Time in shuttle run test (s)	329 ± 122	242 ± 185	<0.05
Girls (*n*)	307	203	
VO_{2max} (mL/kg per min)	46.02 ± 3.76	44.67 ± 3.86	<0.05
Time in limb movement (s)	18.88 ± 4.54	19.22 ± 4.58	NS
Flexibility (cm)	19.82 ± 5.38	18.90 ± 5.67	0.07
Jump performance (cm)	120.14 ± 26.12	115.50 ± 25.06	<0.05
Handgrip (kg)	15.13 ± 5.04	14.68 ± 4.68	NS
Sit-ups (n)	17.33 ± 5.48	16.39 ± 6.24	0.08
Bent arm hang (s)	8.16 ± 8.24	6.60 ± 8.18	<0.05
Time in run speed test (s)	23.79 ± 2.52	24.36 ± 2.30	<0.05
Time in shuttle run test (s)	260 ± 123	321 ± 92	<0.05

VO_{2max}, maximal oxygen uptake; NS, not significant. Unpaired *t* test, mean ± standard deviation.

that the highest prevalence of overweight and obesity in Spain was found in those population areas ranging from 10,000 to 50,000 inhabitants. Furthermore, large population communities (>350,000) had similar prevalences to small communities (<10,000) (3). In the region of Aragón, we found only one study that evaluated this matter (6), showing that the risk of being overweight was higher in the rural (<10,000) compared with the urban (>10,000) areas, par-

Table 3. Multiple regression linear analyses with BMI, whole body, and truncal subcutaneous fat mass as dependent variables and both VO_{2max} and PA levels as explaining variables, by gender in children from Aragón (7 to 12 years of age)

	BMI			SSF			STF		
	β-coefficient	**SE**	***p***	**β-coefficient**	**SE**	***p***	**β-coefficient**	**SE**	***p***
VO_{2max} (mL/kg per min)									
Boys	−0.047	0.005	0.000	−3.334	0.256	0.000	−1.776	0.143	0.000
Girls	−0.059	0.008	0.000	−2.571	0.216	0.000	−1.765	0.165	0.000
PA levels (>2 hours/wk)									
Boys	0.145	0.050	0.004	4.276	2.364	0.081	2.231	1.322	0.092
Girls	0.015	0.057	0.785	−1.396	2.095	0.505	−0.310	1.225	0.800

VO_{2max}, maximal oxygen uptake; PA, physical activity; SSF, 6 skinfolds thickness; SFT, truncal subcutaneous fat; SE, standard error. VO_{2max} and PA levels were adjusted for living area and age.

ticularly in the females at 6 to 7 years and in the males of 13 to 14 years of age. However, in our study, we did not observe the same tendency, as the prevalence of being overweight and obese was similar in rural and urban groups. One possible explanation for these differences could be the different proportions of physically active compared with non-physically active children included in each study. Urban-rural differences in obesity usually have been attributed to different levels of PA and dietary changes (6).

Physical Fitness vs. PA Level as Determining Factors for the BMI and SSF Values

Multiple regression analysis showed that, in our representative population of children, the PA level seemed to be a determining factor and had a significant effect only in the boys (likely through its effects on the lean mass during growth). Cardiorespiratory fitness (maximum oxygen consumption) was the strongest factor that influenced the BMI, SSF, and SFT values according to the statistical analysis performed. These results are in agreement with several studies showing that cardiovascular fitness is preferred to physical activity levels in adolescents (13 to 18.5 years of age) and that cardiovascular fitness can be used to detect those children with enhanced risk of cardiovascular disease (16–18). In our study, aerobic capacity can explain between 37% to 43% of the BMI variability and 48% to 49% of the sum of the skinfold thickness variability. The latter implies that, even in children 7 to 12 years of age, not only are PA levels important, but aerobic fitness can also be used as a good predictor for some health risks in children (hyperinsulinemia, hypercholesterolemia, and others) (19,20). Lastly, in our study, the living area (rural or urban) did not have a significant effect on the BMI, SSF, or SFT values.

In summary, as a result of the data included in the present investigation, we can conclude that one of the regions with the lowest proportion of overweight and/or obese children in Spain (Aragón) has rapidly reached rates similar to the mean previously published for children 7 to 12 years of age. The living area (urban or rural) does not seem to have any important effect on the BMI values of these children. However, the practice of sports outside the school schedule (at least 2 hours per week) seems to be a protecting factor to diminish the accumulation of whole body subcutaneous fat mass and to improve the physical fitness among children 7 to 12 years of age of this region. The use of BMI as an obesity index could lead to a wrong interpretation in the active children, especially in the boys. Lastly, cardiorespiratory fitness is an important factor that affects BMI and SSF accumulation values in the representative sample of the study. Further research including data about the lifestyle factors is needed to better understand these increasing rates found in the present investigation.

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