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Casajús, J.A.; Ortega, F.B.; Vicente-Rodríguez, G.; Leiva, M.T.; Moreno, L.A. y Ara, I. (2012). Condición física, distribución grasa y salud en escolares aragoneses (7 a 12 años) / Physical fitnnes, fat distribution and health in school-age children (7 to 12 years). Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte vol. 12 (47) pp. 523-537 Http://cdeporte.rediris.es/revista/revista47/artcondicion307.htm

ORIGINAL

PHYSICAL FITNNES, FAT DISTRIBUTION AND HEALTH IN SCHOOL-AGE CHILDREN (7 TO 12 YEARS)

CONDICIÓN FÍSICA, DISTRIBUCION GRASA Y SALUD EN ESCOLARES ARAGONESES (7 A 12 AÑOS)

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FINANTIAL SUPORT

This work was supported by Gobierno de Aragón (No.B%//99) and Ministerio de Ciencia e Innovación de España (Red de investigación en ejercicio físico y salud para poblaciones especiales-EXERNET-DEP2005-00046/ACTI) and Instituto de Salud Carlos III (Red SAMID, Nº DR08/0072). There are no potential conflicts of interest that may affect the contents of this work. Actually Francisco Ortega is granted by Ministerio de Educación y Ciencia (AP-2004-2745).

Código UNESCO / UNESCO Code: 5899 Educación Física y Deportiva / Physical Education and Sport
Clasificacion del CONSEJO DE EUROPA / Council of Europe classification: 11 Medicina del Deporte / Sport Medicine

Recibido 13 de octubre de 2010 **Received** October 13, 2010
Aceptado 20 noviembre 2010 **Accepted** November 20, 2010

ABSTRACT

The association between physical fitness, adiposity and trunk fat mass during childhood and cardiovascular health later in adult life has been well established. Aim: to determine the physical fitness levels of children (7-12 y) and their relationship with a healthy aerobic fitness level and fat distribution.

A cross sectional study including 1068 boys and girls aged 7-12 y was performed. Anthropometric measurements and Eurofit battery test were used.

A full set of physical fitness reference values for school age children (7-12 y) is presented. A percentage of 9.1 of boys and 4.8% of girls, do not accomplish the minimum levels recommended for a healthy cardiovascular fitness. A relationship between high physical fitness levels and low subcutaneous fat mass (whole body and the trunk area) was observed.

The inclusion of physical fitness and body fat distribution assessment in the health screening programs in children is of clinical and social relevance.

KEY WORDS: aerobic fitness, cardiovascular risk, fat distribution, body mass index, children.

RESUMEN

La condición física, adiposidad y distribución grasa observadas en la infancia, han mostrado tener relación con la salud cardiovascular en la edad adulta. Objetivo: evaluar el nivel de condición física en escolares de 7 a 12 años y su relación con niveles saludables de condición aeróbica y distribución grasa.

Se valoraron 1068 niños y niñas aragoneses de 7-12 años de edad. Se evaluó la condición física con la batería Eurofit y el grado de adiposidad y distribución grasa mediante antropometría.

Se obtienen valores normativos de condición física. Un 9,1% de los chicos y 4,8% de las chicas presenta riesgo fututo de salud sobre la base de su condición aeróbica. Mejor condición aeróbica se asocia con cantidades significativamente menores de grasa subcutánea total y en el tronco.

Es importante incorporar la evaluación del nivel de condición física y distribución grasa en la valoración del riesgo de salud desde edades tempranas.

PALABRAS CLAVE: condición aeróbica, riesgo cardiovascular, distribución grasa, índice de masa corporal, niños.

INTRODUCTION

A new concept of physical fitness closer to the field of health has emerged during the decade of the seventies of the XX century. This concept takes as main purpose the individual wellbeing over the traditional sport performance, contributing to an ideological rupture. In 1989 Blair et al.[1] were the first to use cardiovascular condition in clinical practice has an indicator of health status. Current scientific evidence demonstrates that the level of physical fitness is a powerful predictor of morbidity and mortality, due to cardiovascular or other causes independently of health status, with or without overweight[1-3], being also a determinant longevity factor[4]. Therefore, there has been a special interest and increase in research studying the association between physical fitness and health in children and adolescents. This topic has been recently reviewed by Ortega et al.[5], that concluded that physical fitness levels are a powerful biomarker of health status from early childhood. Similarly, it has been observed that children who perform higher amounts of physical activity have a healthier body fat distribution and cardiovascular fitness[6-8]. Moreover, several studies have demonstrated an association between the level of physical fitness in infancy/adolescence and cardiovascular risk in later stages of life[7, 9-12]. Other studies have concluded that trunk body fat accumulation is a determinant factor in the appearance of cardiovascular and metabolic diseases[10, 13, 14].

The aims of this study were: 1) to determine reference values for physical fitness in youth Aragonesse schoolchildren from 7 to 12 years old that help specialists to interpret the results of children at this age-range; 2) to describe the proportion of children that do not reach minimum aerobic fitness values and therefore are at a higher risk of future disease, and 3) to relate the level of physical fitness with a healthy body fat distribution.

RESEARCH METHODS AND PROCEDURES

Experimental Design

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. All children answered a questionnaire providing information about medical history. Exclusion criteria included chronic-diseases and currently taking any kind of medication that could affect sexual maturation or muscle mass development. The study was performed in accordance with the Helsinki Declaration of 1975 (reviewed in Hong-Kong in 1989) with regards to the conduct of clinical research, fulfilling all the good clinical practice principals included in the CEE (document 111/3976/88, 1990) and in accordance with the legal regulation for clinical research in humans of Spain.

Sample selection

A random sample of 1068 healthy Caucasians 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 Aragon, Spain (maximum error 3 % with 95% confidence) according to the information provided by the Instituto Aragonés de Estadística (IAE). The data were recorded during the scholar course 1999-2000. In the first step, stratification was performed by sex, educational level, state and residential (urban/rural) area (cut-off point of 10.000 habitants) 6 with a proportionate affixation proportional to the size of stratification; in the second stage a randomize by cluster with schools at the primary sampling cluster was used.

School centers selection was made with the same probability rate of being selected and without reposition among each of the strata. In Zaragoza the distribution patters was made according to official data (Servicio Provincial de Educacion). The same pattern was used neither in Huesca nor in Teruel due to the reduced population size. In each region all schools centers (public, private, mixed) were selected and divided according to its precedence (rural/urban). Participation rate was 90%.

Anthropometry

All anthropometric measurements were performed by two experienced physicians (Level 2 and Level 3) according to the well-standardized procedures of the International Society for the Advancement in Kinanthropometry (ISAK)[15]. Technical error measurement were among permitted levels (<5% for skinfold thickness and <1% for the rest of measures)

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). Skinfold thickness was measured at biceps, triceps, subscapular, suprailiac, abdominal, and medium calf sites with a Holtain skinfold caliper (Holtain Ltd, Crosswell, United Kingdom). 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 as adiposity and fat distribution indexes. The body mass index was calculated as weight (kg) / height^2 (m).

Physical fitness

Physical fitness was determined using eight physical fitness tests included in the Eurofit Fitness Testing Battery Eurofit[16] previously validated and standardized by the European Commission in the following order: Plate Tapping, Sit-and-Reach, Standing Broad Jump, Handgrip Test, Sit-Ups in 30 seconds, Bent Arm Hang, 10 x 5 meter Shuttle Run and 20 m endurance shuttle-run.

The cardio-respiratory fitness was estimated using the results of a maximal multistage 20-m shuttle running test. 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 signals 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} with the following formula $VO_{2max} = 31{,}025 + 3{,}238\ (V) - 3{,}248\ (A) + 0{,}1536\ (A)$[17], where V is the velocity in $km{\cdot}h^{-1}$ reached at the last stage and A represents the age of the children. This test has shown to be valid and reliable for the prediction of the VO_{2max} in children[17].

Cut-off physical fitness values (42 and 38 mL/kg/min for boys and girls respectively)[18] were used to divided children in two groups: high and low cardiorespiratory fitness levels (High CRF and Low CRF).

Statistical Analysis

LMS Method in Smoothing Reference percentile Curves was applied[19], using the lmsChartMaker Pro version 2.3 software (Medical Research Council 1997-2006). A one-way ANCOVA test using age as a covariate was used to assess the group differences in physical fitness, BMI, sum of skinfold thickness between high and low physical fitness groups. Good/bad physical fitness was used as a fix factor while physical fitness, BMI, sum of skinfolds were introduced in the model as continuous variables. SPSS package (SPSS, Inc., Chicago, IL) software was used for the statistical analysis. The significance level was set at $p < 0.05$, and data are represented as means ± standard deviation unless otherwise stated.

RESULTS

Sex- and age-specific centile (P5, P25, P50, P75 and P95) curves for the different physical fitness tests are shown in Figures 1 to 3. Overall, physical fitness improved across age categories, except for flexibility that was similar in all age groups. It is interesting to highlight that cardiorespiratory fitness, as expressed by VO2max relative to body weight is the only fitness variable that decreased as age increased in girls. Overall, centile curves were similarly homogenous in boys and girls.

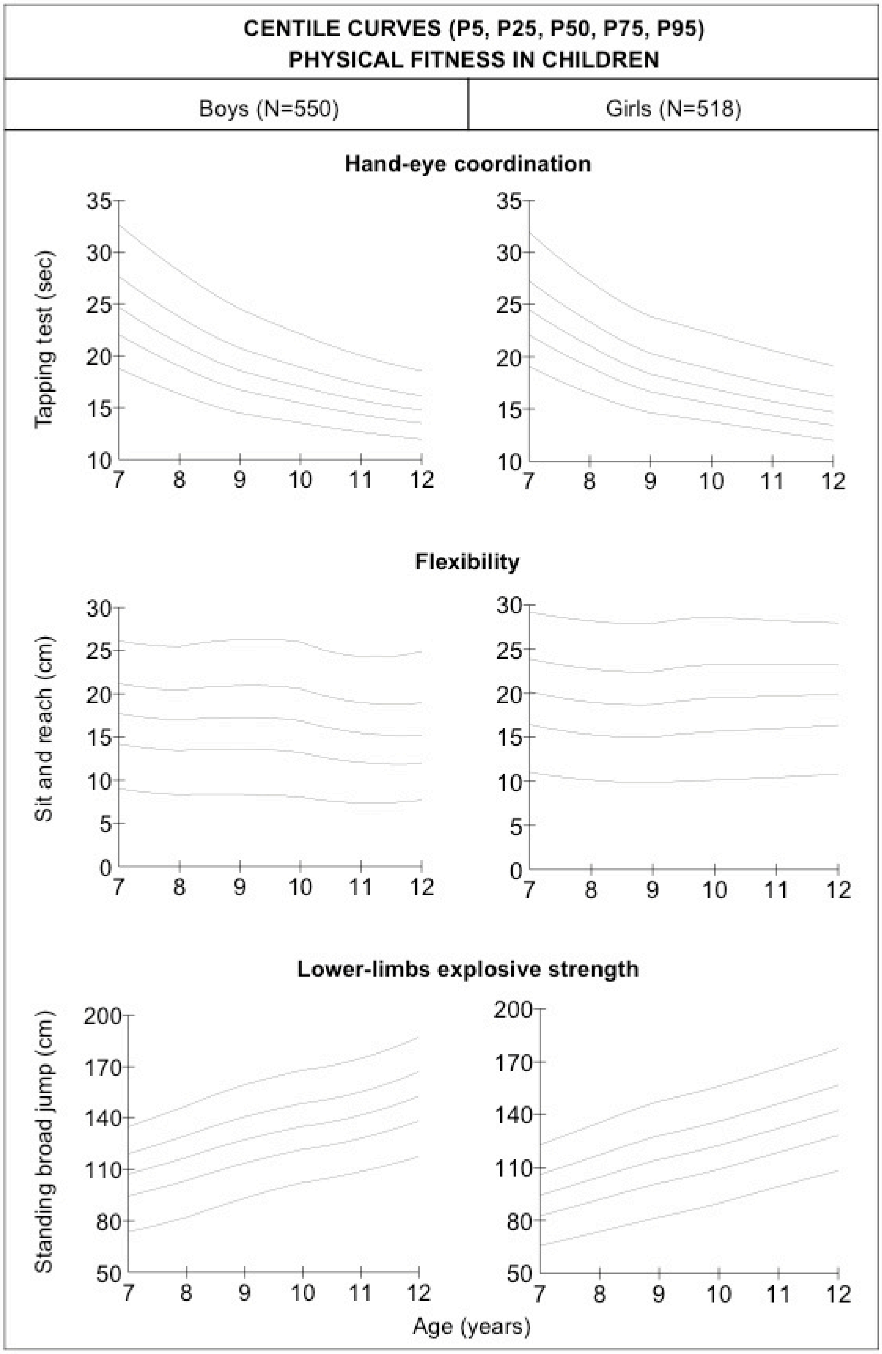

Figure 1. Smoothed centile curves (LMS Method) for three physical fitness components: eye-hand coordination, flexibility and lower-limbs explosive-strength. From the bottom to the top: P5, P25, P50, P75 and P95.

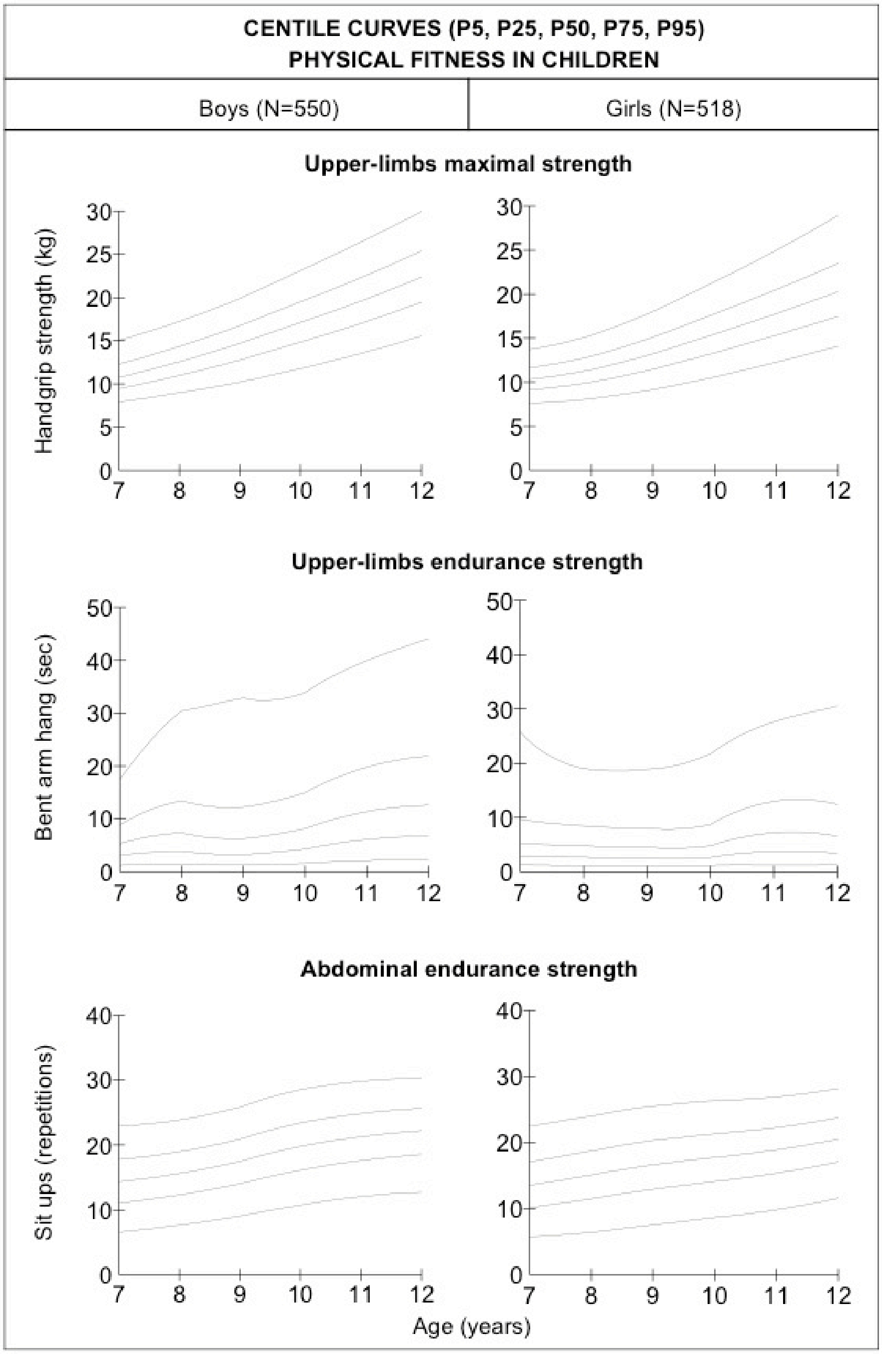

Figure 2. Smoothed centile curves (LMS Method) for three physical fitness components: handgrip maximal-strength, upper-limbs endurance-strength and abdominal endurance-strength. From the bottom to the top: P5, P25, P50, P75 and P95.

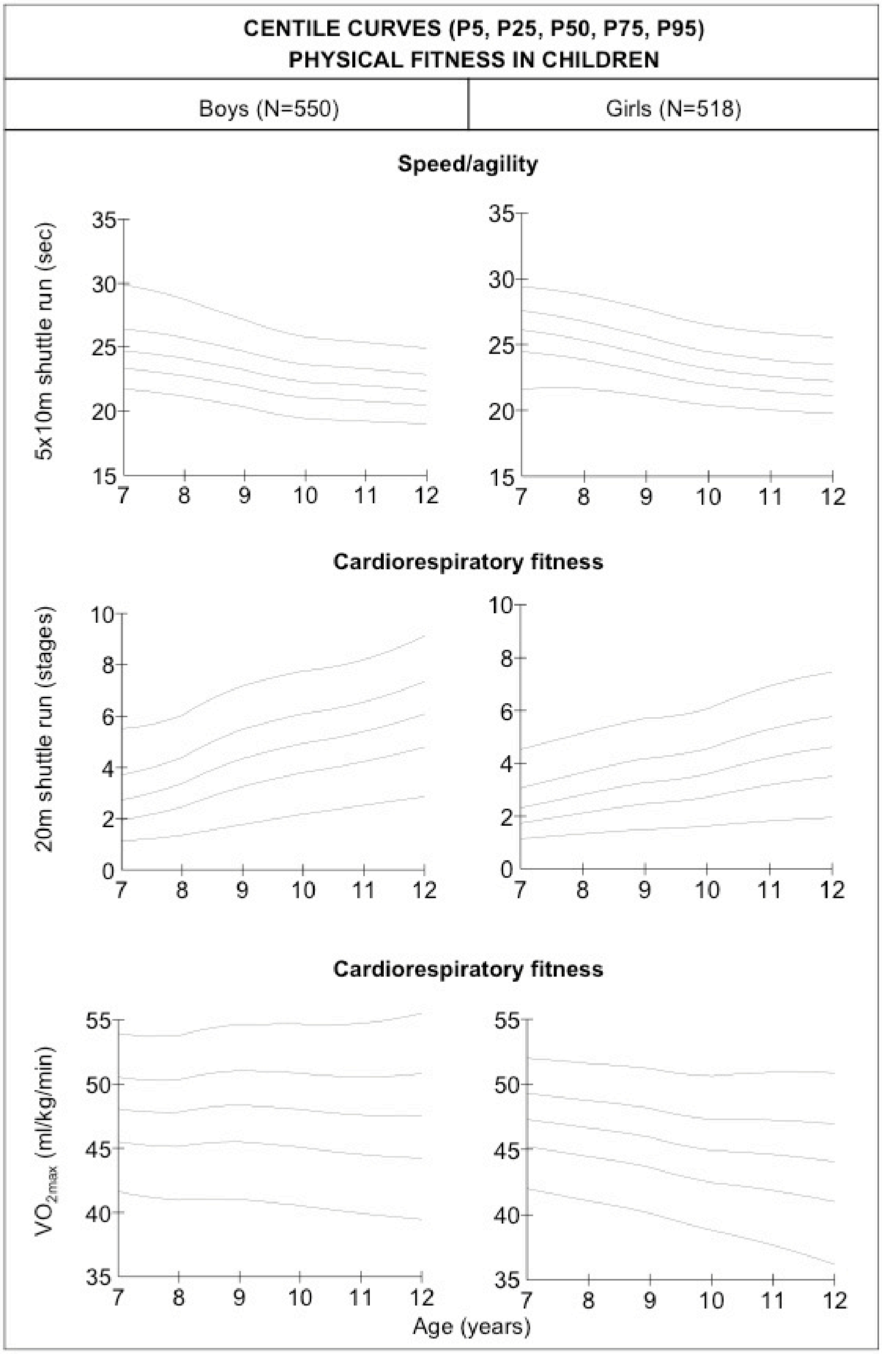

Figure 3. Smoothed centile curves (LMS Method) for two physical fitness components: speed-agility and cardiorespiratory fitness. From the bottom to the top: P5, P25, P50, P75 and P95.

Table 1 shows the characteristics of the study sample by age, sex and cardiorespiratory fitness group, as well as the percentage of participants classified as having a higher cardiovascular risk due to their low cardiorespiratory fitness levels, using the VO2max cut-points available in the scientific literature[18, 20]. 9.1% of the boys (39.7 mL/kg/min, 95% CI 39.3 to 40.1) and 4.8% of the girls (36.6 mL/kg/min, 95% CI 35.9 to 37.3) failed to meet the recommended fitness level for better cardiovascular health.

Table 1. Characteristics of the study sample by age, sex and cardiorespiratory fitness level.

	Boys		Girls	
	High CRF	Low CRF	High CRF	Low CRF
Number of subject (n)	500	50 (9,1%)	493	25 (4,8%)
Age (years)	9,6 ± 1,7	10,0 ± 1,5	9,4 ± 1,7	11,7 ± 0,6$
Weight (kg)	34,3 ± 9,6	43,0 ± 14,0*	34,1 ± 9,5	49,6 ± 10,1*
Height (cm)	136,5 ± 11,0	139,8 ± 12,0	135,4 ± 11,8	149,5 ± 7,7
IBM	18,1 ± 2,9	21,4 ± 4,6*	18,3 ± 2,9	22,1 ± 4,0*
Sum of 6 skinfolds (mm)	59,4 ± 26,7	95,0 ± 39,0*	72,1 ± 24,6	102,5 ± 32,0*
Sum of trunk skinfolds (mm)	24,1 ± 14,4	45,2 ± 24,3*	29,2 ± 14,0	49,6 2± 0,7*
Plate tapping (s)	18,7 ± 4,7	18,3 ± 3,4	19,1 ± 4,6	15,9 ± 2,5
Seat and reach (cm)	16,9 ± 5,2	14,0 ± 6,1*	19,5 ± 5,5	19,0 ± 5,0
Long jump (cm)	132,0 ± 25,3	119,6 ± 23,4*	117,7 ± 25,5	129,4 ± 27,4*
Handgrip (kg)	16,5 ± 5,2	17,9 ± 5,5	14,7 ± 4,8	20,0 ± 4,3
Sit-ups (n)	18,8 ± 5,9	16,2 ± 6,0*	16,9 ± 5,8	17,8 ± 6,5
Bent Arm Hang (s)	12,2 ± 11,2	5,0 ± 6,5*	7,8 ± 8,3	3,1 ± 3,5*
Shuttle run test (10 x 5) (s)	23,0 ± 2,4	24,4 ± 2,5*	24,0 ± 2,5	23,5 ± 2,0*
VO_{2max} (mL/kg/min)	48,6 ± 3,6	39,7 ± 1,4*	45,9 ± 3,4	36,6 ± 1,8*

Data are presented as mean ± SD. CRF = Cardiorespiratory fitness
$ p<0.005 High CRF vs. Low CRF
* p<0.005 High CRF vs. Low CRF, age as a covariate

Boys in the high aerobic fitness group performed better than their peers in the low aerobic fitness group in all physical fitness tests (P<0.05) except for the tapping test and handgrip strength test (P>0.05). In girls, the high aerobic fitness group performed better only in the bent arm hang test and VO2max, while the low aerobic fitness group performed better in the rest of fitness tests (P<0.05).

Regarding anthropometry and adiposity, similar findings were observed in boys and in girls: weight, sum of 6 skinfolds, sum of trunk skinfolds and BMI were significantly lower in the group with high aerobic fitness (P<0.05). No differences were observed in height.

Figure 4 shows that for a given total fatness, boys and girls in the high aerobic fitness group have a lower amount of trunk fat, compared with their peers in the low aerobic fitness group.

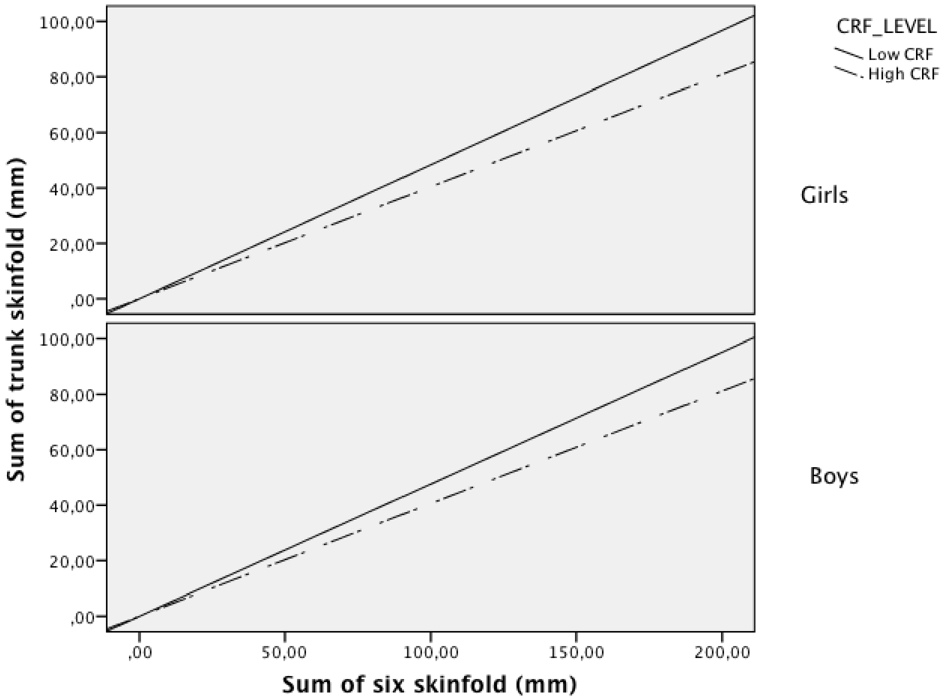

Figure 4. Relationship between the sum of 6 skinfolds (total fatness) and the sum of trunk skinfolds (trunk fatness) in boys and girls according to the level of aerobic fitness.

DISCUSSION

As it has been previously indicated, the sample correspond to an specific geographic zone in North Spain, Aragón, therefore, the results should not interpreted as representative of the whole country. Anyhow, the Aragon´s socioeconomic characteristic and the absence of bias in the sample make these results valid for the studied age range.

With these limitations, present results provide normalized data that may be useful at health care, education and sportive levels. In this sense, it is of particular interest identifying boys and girls with fitness levels pathologically low, it means under 5th percentile (figures 1-3), as it place these children in a risk condition that may be reversed. The earlier the detection, the higher the successful provability trying to modified it. Our results provide similar data in both genders contrarily to those reported for Ortega et al.[21] in Spanish adolescent population. The growth spurt and the associated anatomic, physiologic and psycho-social changes, especially in girls, may explain at least part of this discrepancy. As noted by Bar-Or[22] the characteristics and physiological response of boys and girls before adolescence are quite similar and homogeneous.

The results of this study shown that 9.1% of the boys and 4.8% of the girls have a level of cardiovascular fitness indicative of higher risk for health. These percentages are clearly lower than those referred in Spanish adolescents (19.3 and 17.2% respectively)[21], suggesting a possible deterioration of this fitness component with the adolescence. The age ranges studied (7-12 and 13-18 years old) coincide with the first (primaria) and second (secundaria) education steps in Spain, which come with a significant change in the academic curriculum and in physiologic and social changes. It is needed to deep on these aspects to identify factors associated to this level-up tendency in cardiovascular risk factors and modify them.

Tomkinson et al.[23] carried out a meta-analysis including 55 references analysing the secular tendency on cardiovascular fitness (Course Navette), in boys and girls from 1980 to 2000. The results indicated that aerobic fitness decreased 0.46% in boys and 0.41% in girls per year, being the decrease higher in adolescents than in children. Malina[24] provided similar results in American population. These tendencies, joined to the percentages of low aerobic fitness observed in the present Study should alert health care and education authorities to prevent the lost of cardiovascular health at school ages.

In general, children with good aerobic fitness also showed higher performance in most of fitness tests, which suggest that aerobic component, is a good indicator of general fitness at these ages. Nevertheless, in girls the results are different obtaining the low aerobic group better results in power and speed tests. In both, boys and girls, strength in manual dynamometry is higher in those with lower aerobic fitness, although did not showed significant differences. These results agree with the argue that overweigh and obesity are associated better performance in this test[25] due to overweight and obesity are also associated to the increase in lean mass[26] that may rally on those explosive or short-duration tests[25]. In addition, other factors such as pubertal maturation, dynamometer grip or muscle mass in the extremities may be also taken into consideration and need further research.

Present findings support the idea that children between 7 and 12 years old showing a good aerobic fitness accumulate significantly less subcutaneous fat (both at whole body and trunk region) compared to those not reaching the recommended aerobic level. Additionally, for a specific amount of fat, aerobic fitness seems to produce a healthy effect on its distribution associated to a lower accumulation at central level.

These results are in line with those reported by other authors[13, 27, 28] showing in children and adolescents that those with higher cardiovascular level had lower amount of abdominal fat mass (waist circumference). Similarly, Ara et al.[29, 30] showed that those active children present better aerobic fitness and lower accumulation of fat mass in the trunk and whole body with growth. Janssen et al.[31] also referred that fitness level is related to intraabdominal fat (computed tomography) although without BMI modification.

All together, suggest that aerobic fitness level may attenuate risk factors associated to overweight and related pathologies, distinguish the importance of aerobic fitness in its prevention and treatment from childhood. On the other hand, this evidence that information reported by BMI as unique anthropometric indicator of health risk in these ages is limited. The incorporation of other indicators such as central fat and aerobic fitness level should be basic in the clinic daily practice.

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