Low Level of Physical Fitness in Spanish Adolescents. Relevance for Future Cardiovascular Health (AVENA Study)

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Introduction and objectives. Several studies have demonstrated that physical fitness in childhood and adolescence is related to cardiovascular risk in adulthood. Current data on the physical fitness of Spanish adolescents are not available. Therefore, the aims of this study were: *a*) to assess the physical fitness of Spanish adolescents and establish reference values for use in health and educational settings as indicators of cardiovascular health, and *b*) to determine the percentage of Spanish adolescents below the minimum level of aerobic fitness needed to guarantee future cardiovascular health.

Subjects and method. The modified EUROFIT battery of tests was used to assess physical fitness in a representative sample of Spanish adolescents (n=2859; 1357 boys and 1502 girls) taking part in the AVENA *(Alimentación y Valoración del Estado Nutricional de los Adolescentes)* study.

Results. Standard parameters for the physical fitnes of Spanish adolescents are reported in this study. The 5th percentile for maximum aerobic capacity (Course Navette test) ranged from 2.0-3.3 stages in boys and from 1.4-1.9 stages in girls. The findings indicate that, on the basis of aerobic fitness, approximately 20% of Spanish adolescents have an increased risk of future cardiovascular disease. This subgroup also performed poorly in all other tests of physical fitness used.

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Conclusions. The results reported in this study enable the level of physical fitness in adolescents to be interpreted as an indicator of future cardiovascular health. They also indicate that the physical fitness of Spanish adolescents must be improved to help protect against cardiovascular disease in adulthood.

Key words: *Fitness. Adolescents. Cardiovascular risk.*

Bajo nivel de forma física en los adolescentes españoles. Importancia para la salud cardiovascular futura (Estudio AVENA)

Introducción y objetivos. En diversos estudios se ha mostrado la relación entre el nivel de forma física durante la infancia-adolescencia y el riesgo cardiovascular en la edad adulta. Dado que no se dispone de datos relativos al nivel de condición física de los adolescentes españoles, los objetivos de este estudio son: *a*) determinar el nivel de condición física de los adolescentes españoles y establecer valores de referencia que puedan ser utilizados en el medio sanitario y educativo como indicadores de salud cardiovascular, y *b*) conocer la proporción de adolescentes españoles que no alcanza valores de capacidad aeróbica indicativos de salud cardiovascular futura.

Sujetos y método. Se ha utilizado la batería EUROFIT modificada para evaluar la condición física de una muestra representativa de adolescentes españoles (n = 2.859; 1.357 varones y 1.502 mujeres) procedente del estudio AVENA (Alimentación y Valoración del Estado Nutricional de los Adolescentes).

Resultados. Se han obtenido los valores normativos de condición física de la población adolescente española. El rango del percentil 5 respecto a la capacidad aeróbica máxima (test de Course Navette) es de 2,0-3,3 y 1,4-1,9 *paliers* para varones y mujeres, respectivamente. Casi 1 de cada 5 adolescentes presenta riesgo cardiovascular futuro sobre la base de su capacidad aeróbica. Este subgrupo de adolescentes mostró también una peor forma física que el resto de adolescentes en todas las pruebas físicas realizadas.

Conclusiones. Los resultados obtenidos en el presente estudio permiten evaluar e interpretar correctamente el

ABBREVIATIONS

VO_{2max}: maximal oxygen consumption.

nivel de forma física de cualquier adolescente. Los resultados obtenidos indican la necesidad de mejorar el nivel de condición física de los adolescentes españoles.

Palabras clave: *Forma física. Adolescentes. Riesgo cardiovascular.*

INTRODUCTION

Recent studies have shown that aerobic capacity and muscle strength are powerful predictors of cardiovascular and all-cause death and disease, both in men[1-3] and in women.[2-5] The role of poor physical fitness as a cardiovascular risk factor is even greater than other well established factors, such as dyslipidemia, hypertension, or obesity.[6]

Although the clinical manifestations of atherosclerotic cardiovascular disease usually appear in adulthood, the pathogenic commencement of the disease occurs in childhood or adolescence,[7,8] and cardiovascular risk factors have even been identified at these ages.[9-12] Some of these factors may be able to predict future death and disease, as is the case for overweight children.[13] The study of these factors during the crucial stage of adolescence is, therefore, relevant for the diagnosis and prevention of conditions associated with cardiovascular disease in adults. Several cross-sectional studies have demonstrated an association between the level of physical fitness during childhood and adolescence and cardiovascular risk factors.[14-16] Likewise, important longitudinal studies have shown that the level of physical fitness in an adult, as well as the presence of other conventional cardiovascular risk factors, such as hypercholesterolemia or hypertension, is conditioned by the level of physical fitness in childhood or adolescence.[17-21] In order, therefore, to evaluate future cardiovascular risk as early as possible, this evaluation should start in childhood or adolescence. However, a correct clinical evaluation of the level of physical fitness requires up-to-date reference values for the study population. Thus, the aim of this study was to establish the normative values for physical fitness in Spanish adolescents.

SUBJECTS AND METHOD

Subjects and Experimental Design

This study formed part of the AVENA (*Alimentación y Valoración del Estado Nutricional en Adolescentes*) Study, whose full methodology has been reported previously.[22] This multicenter study was undertaken in Spanish adolescents from 13-18.5 years of age. In order to account for the heterogeneity of the population, the study was undertaken in both, public and private high schools, or apprentice training schools.

The study was multistage, randomized, and stratified according to origin (Granada, Madrid, Santander, Zaragoza, and Murcia), social and economic condition (according to the site of the educational establishment; data provided by the various regional educational authorities), sex, and age. Exclusion factors included a clinical diagnosis of diabetes, pregnancy, the use of alcohol or drugs, and, in general, the presence of any disease not directly associated with nutrition. Exclusion from the study was made effective *a posteriori*, without the students being aware of it, in order to avoid any undesired situation.

To determine the overall sample size, we used the parameter of greatest variance in the population, obtained from published data at the time the study was planned,[23] that is, the body mass index (BMI). The sampling was determined by this dispersion. The confidence level was 95%, with an error of ±0.25. The number of subjects for the complete study was calculated to be 2100. The total number was distributed equally among the different cities, and proportionally by sex and age group (13, 14, 15, 16, and 17-18.5 years). The sample was overestimated to prevent loss of information. Finally, a weighting factor was applied to balance the sample according to the distribution of the Spanish population and guarantee the true representation of each of the groups defined by the abovementioned factors (Source: National Statistics Institute). After eliminating from the study all those subjects who failed to meet the inclusion criteria, the final number of participants was 2859 (1357 boys and 1502 girls).

The study was undertaken in accordance with the deontological norms laid down in the Helsinki Declaration (Hong Kong revision, September 1989) and the European Union recommendations for Good Clinical Practice (document 111/3976/88, July 1990), and the current Spanish laws governing clinical research in human subjects (Royal Decree 561/1993 concerning clinical trials). The study was submitted for evaluation and approved by the Ethics Committees of the Spanish National Research Council and the Marqués de Valdecilla University Hospital (Santander, Spain).

Evaluation of Physical Fitness

Prior to starting the study, the researchers involved in the project undertook training sessions in order to guarantee the standardization, validation, and reliabili-

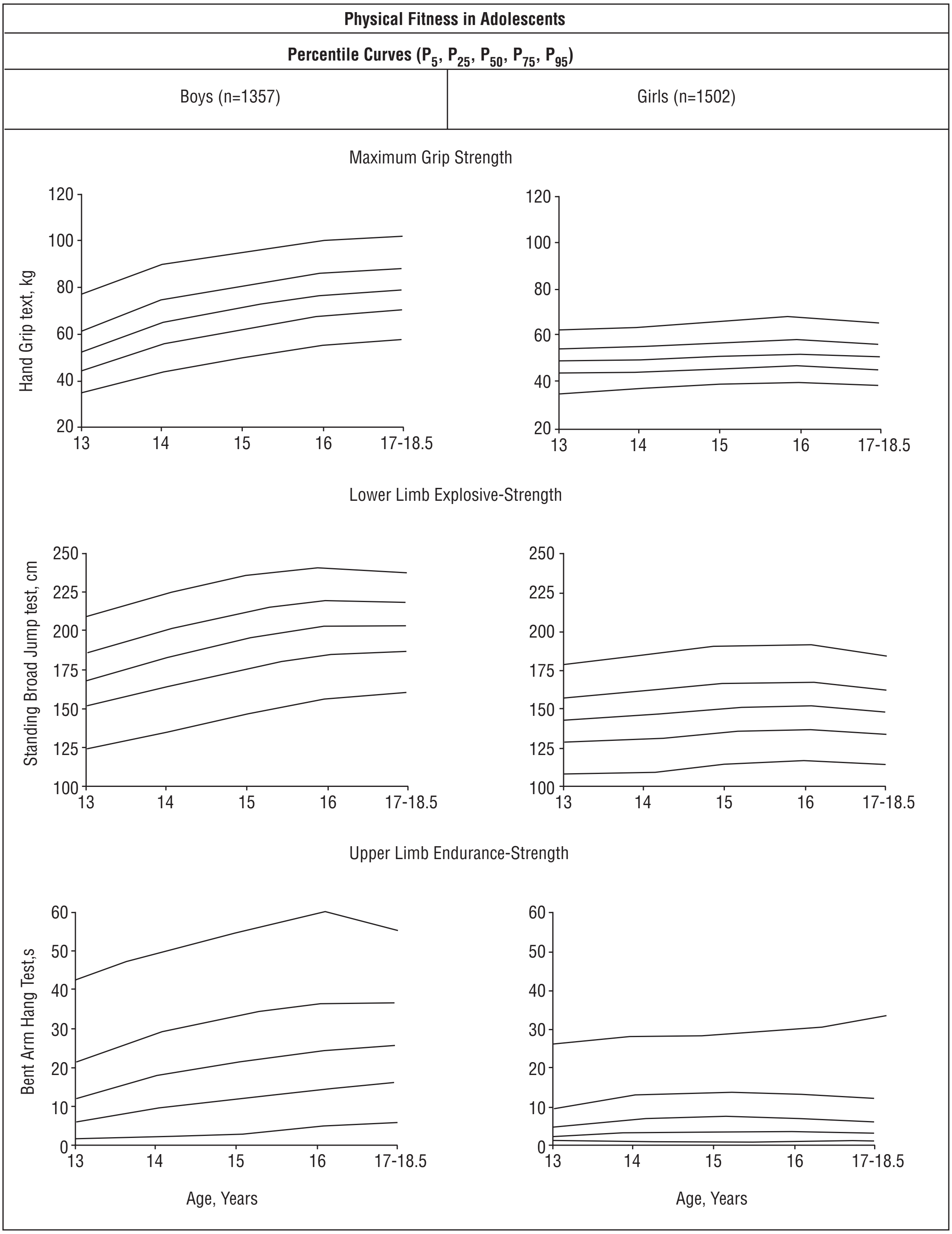

Figure 1a. Percentile curves (from bottom to top: P_5, P_{25}, P_{50}, P_{75}, P_{95}) of 3 tests to measure different manifestations of muscle strength. The smoothing of the percentiles was done with the LMS method.

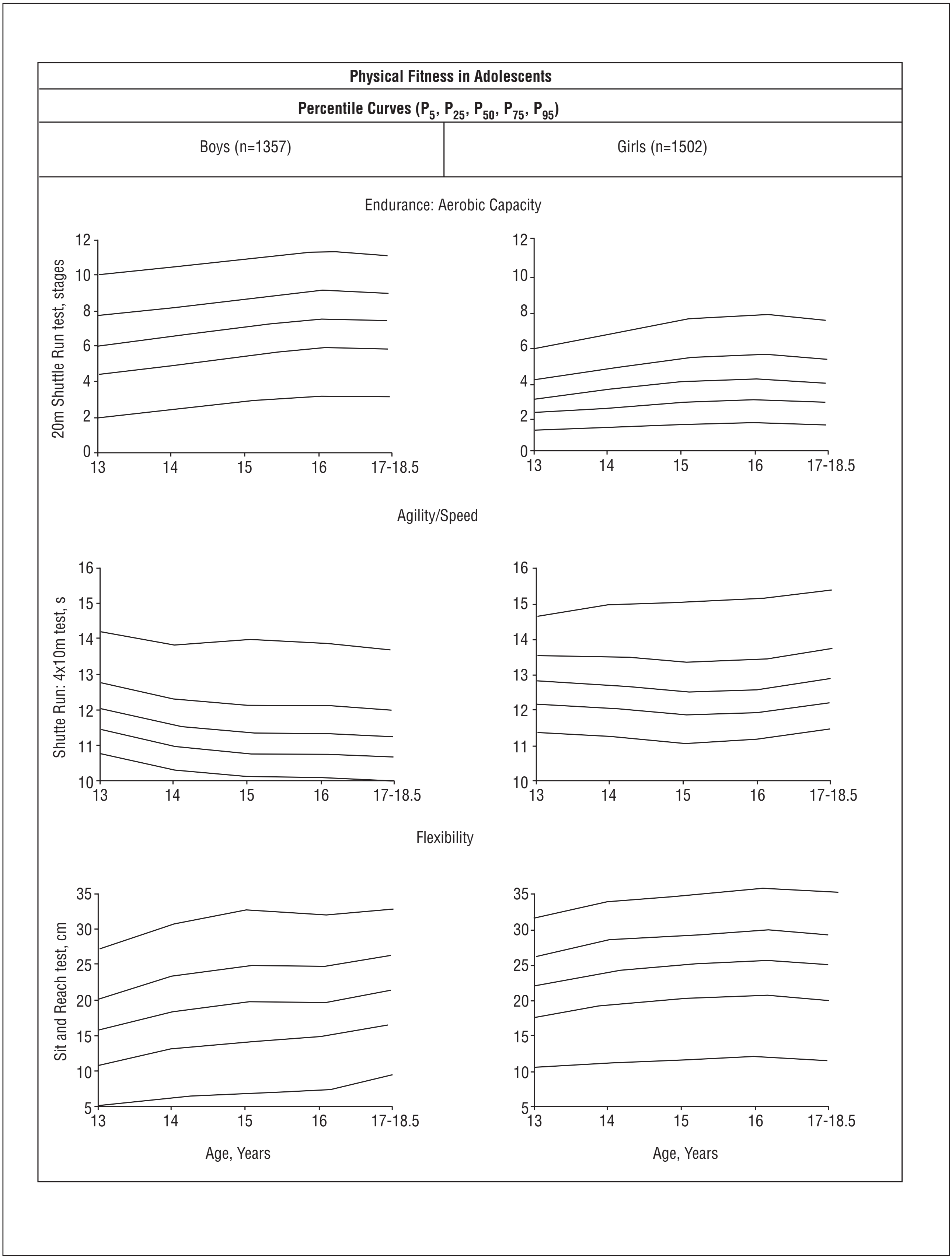

Figure 1b. Percentile curves (from bottom to top: P_5, P_{25}, P_{50}, P_{75}, P_{95}) of 3 tests to measure different physical qualities. The smoothing of the percentiles was done with the LMS method.

ty of the measurements.[24] Six tests, forming part of the EUROFIT[25] battery, validated and standardized by the European Council, were applied in the following order:

1. Sit and Reach test. With the subject seated on the floor and using a standardized support,[26] the maximum distance reached with the tip of the fingers by forward flexion of the trunk is measured. Test indicative of amplitude of movement or flexibility.

2. Hand Grip test. With the use of a digital Takei TKK 5101 dynamometer (range, 5-100 kg), the maximum grip strength was measured for both hands.

3. Standing broad jump test. The maximum horizontal distance attained, with feet together, was measured. This test evaluates lower limb explosive-strength.

4. Bent Arm Hang test. A standardized test was used to measure the maximum time hanging from a fixed bar. This test estimates the upper limb endurance-strength.

5. Shuttle run: 4×10 meters. This test provides an integral evaluation of the speed of movement, agility and coordination. The subject does four shuttle runs as fast as possible between 2 lines 10 meters apart. At each end the subject places or picks up an object (a sponge) beside the line on the floor.

6. 20 metres Shuttle Run test (Course-Navette). This test evaluates the maximum aerobic capacity based on an indirect-incremental-maximum field test involving a 20 meter shuttle run,[27] using the formulas proposed by Léger et al[28] to calculate the maximal oxygen consumption (VO_{2max}). The reliability and validity of the test to predict the VO_{2max} in children and adolescents have been sufficiently demonstrated.[28-30] To obtain the VO_{2max} easily and quickly from the result of the Course-Navette tests it is sufficient to introduce the age (A) and the final speed (S=8+0.5×last stage completed) into the following formula (r=0.7; for children-adolescents from 8-19 years old)[28]:

$$VO_{2max}=31.025+3.238S-3.248A+0.1536SA$$

Statistical Analysis

In the tables with the reference values and percentile curves, the percentiles were smoothed using the Latent Moderated Structural (LMS) method,[31] for which we used the LMS program, version 1.16, designed by Huiqi Pan (Institute of Child Health, 1998-2002). In the second stage of the analysis, the overall sample was divided into 2 groups, one group with an aerobic capacity indicative of future cardiovascular risk and another group composed of the remaining adolescents. For the inferential analysis, designed to detect differences between the 2 groups, we used the non-parametric Mann-Whitney test, after previously verifying the lack of normality of the study variables. The whole statistical analysis was done with the statistical program SPSS, v12.0.1, for Windows XP.

RESULTS

Tables 1-6 show the reference values for physical fitness in the Spanish adolescents, classified according to age and sex, and expressed in smoothed percentiles from 10-100. Figures 1a and 1b show the percentile curves (P5, P25, P50, P75, and P95), for both sexes and by age, of the different tests of physical fitness. The figure clearly shows greater physical aptitude in the boys, except for the sit and Reach test, in which the girls performed better. From both figures it can be seen that the results for the boys were generally more homogeneous than for the girls, regarding physical aptitude. There was also a trend towards increased physi-

TABLE 1. **Normal Values of the Physical Fitness of Spanish Adolescents. Hand Grip test, Kg: Sum of Both Hands (Maximum Grip Strength)**

	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	P_{100}
Girls										
13 years	37.8	40.9	43.6	46.0	48.1	48.1	50.2	52.5	55.1	58.7
14 years	39.2	42.4	44.8	46.9	48.9	48.9	51.0	53.2	55.9	59.8
15 years	40.9	44.1	46.4	48.5	50.6	50.6	52.7	55.1	57.9	62.1
16 years	42.0	45.1	47.5	49.7	51.8	51.8	54.0	56.5	59.6	64.1
17-18.5 years	40.3	43.4	45.7	47.8	49.8	49.8	52.0	54.3	57.2	61.4
Boys										
13 years	37.7	42.2	45.8	49.0	52.2	52.2	55.5	59.2	63.9	70.8
14 years	47.7	53.2	57.3	60.9	64.4	64.4	68.0	71.9	76.7	83.5
15 years	54.3	59.8	64.0	67.6	71.0	71.0	74.5	78.3	82.8	89.1
16 years	59.7	65.4	69.6	73.2	76.6	76.6	80.1	83.9	88.4	94.7
17-18.5 years	61.8	67.5	71.6	75.3	78.7	78.7	82.1	85.9	90.3	96.5

The process was smoothed using the LMS method.

TABLE 2. **Normal Values of the Physical Fitness of Spanish Adolescents. Bent Arm Hang test, (Upper Limb Endurance-Strength))**

	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	P_{100}
Girls										
13 years	1.3	2.0	2.6	3.4	4.4	4.4	5.7	7.5	10.5	17.1
14 years	1.7	2.8	4.0	5.2	6.7	6.7	8.5	10.9	14.5	21.0
15 years	1.7	2.9	4.2	5.6	7.1	7.1	9.0	11.5	15.0	21.1
16 years	1.8	2.8	3.9	5.2	6.6	6.6	8.4	10.9	14.6	21.7
17-18.5 years	1.5	2.3	3.2	4.2	5.5	5.5	7.1	9.5	13.4	21.8
Boys										
13 years	2.7	4.9	7.0	9.3	11.9	11.9	14.9	18.7	23.8	32.6
14 years	4.2	7.4	10.5	13.7	17.0	17.0	20.8	25.4	31.4	41.0
15 years	5.8	9.8	13.5	17.1	20.8	20.8	25.0	29.8	36.1	45.9
16 years	7.8	12.4	16.4	20.2	24.1	24.1	28.4	33.4	39.7	49.4
17-18.5 years	9.5	14.1	17.9	21.5	25.1	25.1	29.0	33.4	38.9	47.2

The process was smoothed using the LMS method.

TABLE 3. **Normal Values of the Physical Fitness of Spanish Adolescents. Standing Broad Jump test, cm (Lower Limb Explosive-Strength)**

	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	P_{100}
Girls										
13 years	116.0	125.2	132.0	137.7	143.2	143.2	148.6	154.4	161.3	170.9
14 years	117.5	127.1	134.2	140.3	146.1	146.1	152.0	158.3	165.8	176.4
15 years	122.1	131.7	138.8	144.9	150.8	150.8	156.8	163.3	171.1	182.1
16 years	124.9	134.0	140.8	146.7	152.3	152.3	158.0	164.3	171.7	182.3
17-18.5 years	121.8	130.5	136.9	142.5	147.8	147.8	153.2	159.0	166.0	175.8
Boys										
13 years	134.3	146.6	155.2	162.4	168.9	168.9	175.3	182.1	189.8	200.3
14 years	146.3	159.3	168.3	175.8	182.6	182.6	189.2	196.2	204.2	215.0
15 years	158.3	171.6	180.7	188.2	195.0	195.0	201.7	208.6	216.5	227.2
16 years	168.0	180.7	189.4	196.5	202.9	202.9	209.2	215.6	223.0	232.9
17-18.5 years	171.2	182.9	190.9	197.5	203.4	203.4	209.1	215.0	221.8	230.8

The process was smoothed using the LMS method.

TABLE 4. **Normal Values of the Physical Fitness of Spanish Adolescents. Shuttle Run: 4×10 meters test, s (Speed-Agility)**

	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	P_{100}
Girls										
13 years	11.2	11.6	11.9	12.2	12.4	12.4	12.7	13.0	13.3	13.8
14 years	11.0	11.4	11.7	12.0	12.3	12.3	12.6	12.9	13.3	14.0
15 years	10.8	11.2	11.5	11.8	12.0	12.0	12.3	12.7	13.2	14.0
16 years	11.0	11.3	11.6	11.9	12.1	12.1	12.5	12.8	13.3	14.1
17-18.5 years	11.2	11.6	11.9	12.2	12.5	12.5	12.8	13.1	13.6	14.3
Boys										
13 years	10.4	10.8	11.0	11.3	11.5	11.5	11.8	12.1	12.5	13.2
14 years	10.0	10.3	10.6	10.8	11.1	11.1	11.4	11.7	12.1	12.8
15 years	9.8	10.1	10.3	10.6	10.8	10.8	11.1	11.4	11.9	12.6
16 years	9.7	10.0	10.3	10.6	10.8	10.8	11.1	11.4	11.9	12.7
17-18.5 years	9.7	10.0	10.3	10.5	10.8	10.8	11.1	11.4	11.9	12.7

The process was smoothed using the LMS method.

cal fitness in the boys as their age increased, whereas the girls showed stability or a slight increase in physical fitness. Figure 1b shows that the 5th percentile range for the boys was 2.0-3.3 stages and for the girls it was 1.4-1.9 stages, corresponding to the results of the 20 metres Shuttle test.

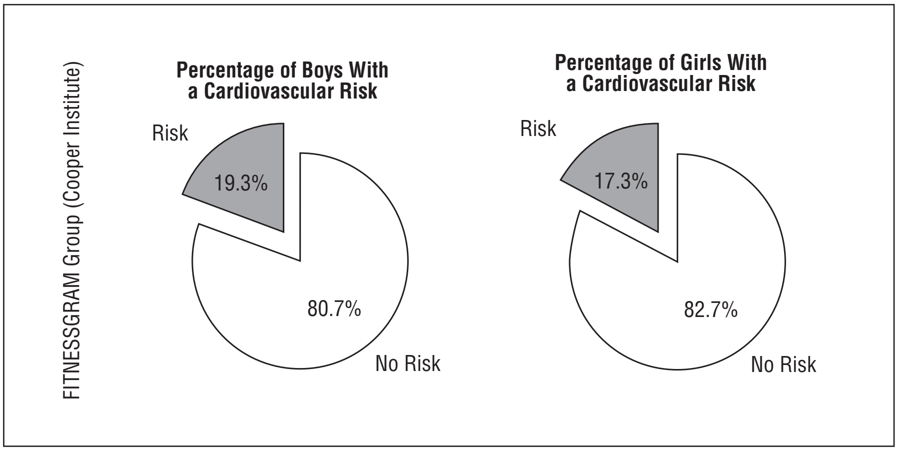

Figure 2. Percentages of adolescents with a cardiovascular risk associated with a low aerobic capacity, using the cut-off points proposed in the literature.[32] The threshold of cardiovascular risk for the boys corresponds to a VO_{2max} of 42 mL/kg/min and for the girls a VO_{2max} of 35 mL/kg/min for girls 14 years or older and 38 mL/kg/min for younger girls.

Figure 2 shows the percentage of Spanish adolescents who presented a future cardiovascular risk, according to their current aerobic capacity, for which we used the VO_{2max} threshold indicative of cardiovascular health proposed in the literature.[32] As can be seen, this percentage surpassed 17%, in both boys and girls. Analysis of the performance shown by this group of adolescents in the other tests shows that the group of adolescents whose aerobic capacity was indicative of future cardiovascular risk also performed worse in the tests measuring the other physical qualities (strength, speed/agility, and flexibility), with significant differences in all the tests undertaken ($P \leq .001$), except in the Hand Grip test in the girls and the flexibility test in the boys ($P \geq .05$) (Figure 3).

DISCUSSION

Prior to explaining and discussing the findings of this study, we shall define and differentiate a few of the terms that are related but nevertheless different, and which are occasionally used mistakenly as synonyms in various references. These concepts are: physical activity, physical exercise, and physical condition or fitness. Firstly, physical activity is any body movement produced by the skeletal muscles and that requires a certain degree of energy expenditure. Physical exercise is included within the concept of physical activity, but the main difference relates to the systematization with which it is undertaken. Invisible exercise is, in turn, an integral part of physical exercise, and is a new concept that includes all those tasks which, with different degrees of intention, adults do every day (cleaning, cooking, going up stairs, walking to different places, etc) and more or less systematically. Finally, physical fitness or physical condition is a concept that encompasses all the physical qualities of a person, and the state of physical fitness can be said to be an integrated part of all the functions and structures involved in the performance of physical exertion.[33]

Reference Values

Determining the individual level of physical fitness in adolescence is important in order to establish the future cardiovascular risk in a particular person.[17-21] Correct interpretation of this information requires comparing it with normative values for the general population. This study reports the reference values for the adolescent population of Spain, and establishes the corresponding percentiles estimated according to age and sex. In population terms, a level of physical fitness below the 5th percentile (Figures 1a and 1b) is potentially pathologic and accurately points to future cardiovascular risk.[20,21] Subjects in this percentile should undergo evaluation for the coexistence of other cardiovascular risk factors. In order to provide a score, for example on a scale of 1-10, we also show the 10th-100th percentiles (Tables 1-6). This enables intuitive classification of the individual level of physical fitness by using a Likert type scale: very poor ($X<P_{20}$), poor ($P_{20} \leq X<P_{40}$), medium ($P_{40} \leq X<P_{60}$), good ($P_{60} \leq X<P_{80}$), and very good ($X \geq P_{80}$). This is especially interesting when the evaluation is done in the health care or educational setting, essential areas for the early detection of problems and immediate intervention. The precision and influence of the particular intervention on the level of physical fitness of an individual or a group can be observed by following the evolution of the percentile lanes. Likewise, it also enables any deterioration due to a certain disease to be measured. Finally, it also enables diagnosis and detection in each person of those physical qualities that are most deteriorated and susceptible to improvement with a physical exercise program.

Comparison With the Situation in Other Countries

To compare the level of physical fitness of Spanish adolescents with that of adolescents in other countries, we compared our results with those reported in 16

TABLE 5. **Normal Values of the Physical Fitness of Spanish Adolescents. 20 metres Shuttle Run test stages (Maximum Aerobic Capacity)**

	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	P_{100}
Girls										
13 years	1.5	1.9	2.3	2.6	3.0	3.0	3.3	3.8	4.3	5.1
14 years	1.7	2.3	2.7	3.1	3.5	3.5	3.9	4.4	5.0	6.0
15 years	2.0	2.6	3.1	3.6	4.0	4.0	4.5	5.0	5.7	6.7
16 years	2.1	2.7	3.2	3.7	4.2	4.2	4.7	5.2	5.9	6.9
17-18.5 years	2.0	2.5	3.0	3.5	3.9	3.9	4.4	4.9	5.5	6.5
Boys										
13 years	2.8	3.9	4.6	5.3	5.9	5.9	6.5	7.1	7.9	8.9
14 years	3.3	4.4	5.1	5.8	6.4	6.4	7.0	7.7	8.4	9.4
15 years	3.8	4.9	5.7	6.4	7.0	7.0	7.6	8.2	8.9	10.0
16 years	4.1	5.3	6.1	6.8	7.4	7.4	8.0	8.7	9.4	10.4
17-18.5 years	4.0	5.2	6.1	6.7	7.3	7.3	7.9	8.6	9.3	10.2

The process was smoothed using the LMS method.

TABLE 6. **Normal Values of the Physical Fitness of Spanish Adolescents. Sit and Reach test, cm (Flexibility)**

	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	P_{100}
Girls										
13 years	13.4	16.4	18.5	20.3	21.8	21.8	23.4	25.0	26.9	29.5
14 years	14.6	18.1	20.4	22.3	24.0	24.0	25.7	27.4	29.3	31.9
15 years	15.2	18.8	21.2	23.2	24.9	24.9	26.6	28.3	30.3	32.9
16 years	15.6	19.4	21.9	23.9	25.7	25.7	27.4	29.2	31.2	33.9
17-18.5 years	14.9	18.6	21.0	23.0	24.7	24.7	26.4	28.2	30.2	32.9
Boys										
13 years	7.3	10.0	12.0	13.8	15.4	15.4	17.1	19.0	21.2	24.2
14 years	8.7	11.8	14.1	16.1	18.0	18.0	19.9	22.0	24.4	27.9
15 years	9.5	12.8	15.3	17.4	19.3	19.3	21.3	23.4	25.9	29.4
16 years	10.0	13.3	15.6	17.6	19.5	19.5	21.4	23.3	25.7	28.9
17-18.5 years	12.2	15.4	17.7	19.6	21.4	21.4	23.2	25.1	27.3	30.3

The process was smoothed using the LMS method.

studies from 11 different countries. Strength (hand dynamometry) and aerobic capacity (VO_{2max}) were the variables chosen for this comparison, as they are the qualities with the greatest cardiovascular interest. The results were made comparable by using, in each case, the same age range, sex, and units of measurement as in the original study. Nevertheless, the methodological differences between the various studies means that the comparisons should be interpreted as approximate.

Muscle strength was measured in 3 studies, undertaken in Sweden,[34] Greece,[35] and the United States.[17] Comparison of our results with those of the studies from these countries shows that Spanish adolescents have, in general, less muscle strength than adolescents in these other countries For aerobic capacity, we reviewed 15 research studies undertaken in the following countries: Netherlands,[36] Belgium,[37] Denmark,[14,16,20] Australia,[38] Greece,[35] Sweden,[15] Portugal,[39] Saudi Arabia,[40] Japan,[41] China,[42] and the United States.[17,43,44] The Spanish adolescents had a worse aerobic capacity than that reported in 11 of the 15 studies. Some of these studies showed an alarmingly progressive worsening in the aerobic capacity of adolescents as compared with the situation in previous decades,[34,38,45] which has been attributed mainly to the increase in sedentary lifestyles in industrialized countries.[38] However, Eisenmann et al[43] state that this trend has only occurred in adolescents ≥15 years of age. Whatever the situation, the decline in aerobic capacity converts the time factor into a contaminating variable when interpreting the results, hindering the use of reference values from studies undertaken in the past and affording greater value to the results of our study, which refer to the current situation.

Aerobic Capacity and Associated Cardiovascular Risk

A key question is whether Spanish adolescents have a satisfactory aerobic capacity (VO_{2max}) in terms of

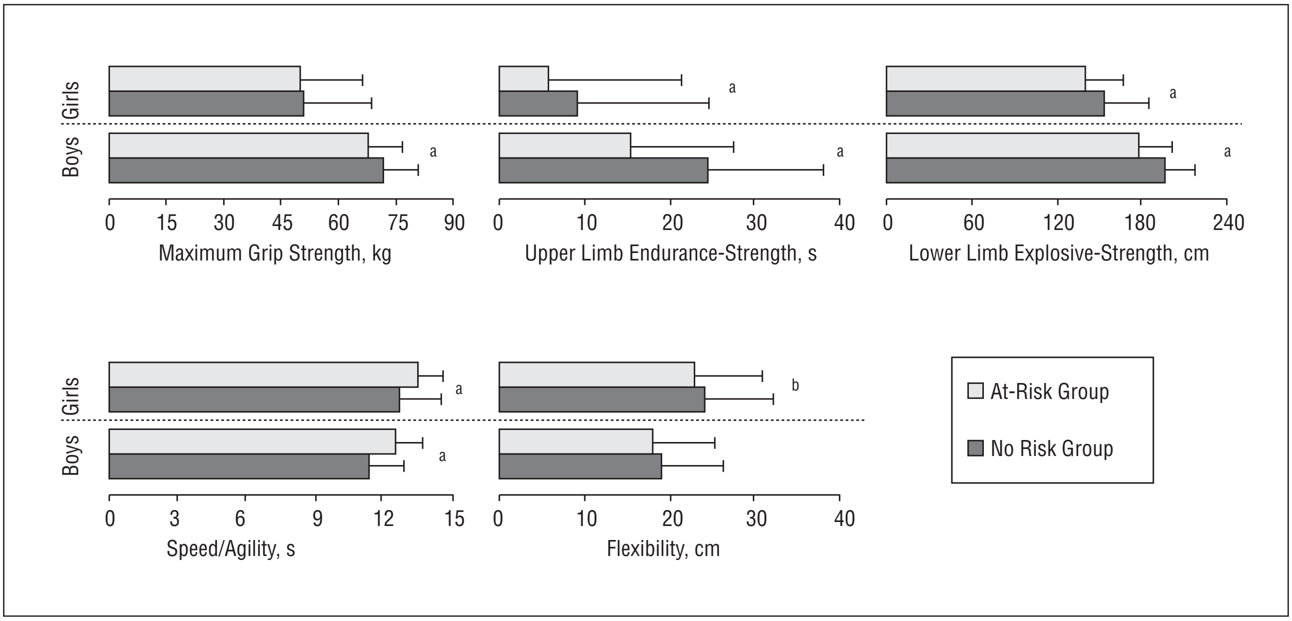

Figure 3. Differences between the group with an aerobic capacity indicative of future cardiovascular risk and the group composed of the other adolescents, for the different physical qualities: muscle strength (Hand Grip test, Bend Arm Hang test, and Standing Broad Jump test), speed/agility (Shuttle Run: 4x10 metres test), and flexibility (Sit and Reach test).
[a]$P\leq.001$. [b]$P\leq.05$.

cardiovascular health. No data are available for Spain, but other data from the scientific literature can be used as a threshold for the beneficial effects on the heart. The cut-off points proposed by the FITNESSGRAM group from the Cooper Institute[32] use well-established thresholds for cardiovascular risk in adults. Likewise, the group estimated the rate of deterioration produced in the VO_{2max} with effect from adolescence, based on several different influential variables (percentage fat mass, age, and level of physical activity) and calculated the lower limit of the VO_{2max} that would represent future cardiovascular risk.[32] This calculation fixed the threshold for cardiovascular health at 42 mL/kg/min for all adolescent boys, whereas for girls older than 14 years of age it was 35 mL/kg/min and 38 mL/kg/min for younger girls. Based on these data, the prevalence of Spanish adolescents with a cardiovascular risk, as defined by their aerobic capacity (estimated with the 20 metres Shuttle Run test) is around 17% for girls and 19% for boys. This represents almost one fifth of all Spanish adolescents, which means that one in five adolescents are currently at risk for presenting some sort of cardiovascular event when they are adults. Clearly, this high prevalence demands specific attention by the various political, health care, and educational authorities. Furthermore, the group of adolescents whose aerobic capacity was indicative of future cardiovascular risk also had a worse performance on the tests of the other physical qualities (strength, speed/agility, and flexibility) (Figure 3). This was even more marked in the case of muscle strength, which also reflects a worse state of health, as strength in an adult has been shown to be a powerful predictor of death and life expectancy,[3,46] and more importantly, expectation of independent life.[47] Thus, in order to improve this situation, programs must be implemented to improve the physical fitness of adolescents. Physical activity is 1 of the 4 prevention strategies for chronic diseases proposed by the World Health Organization in 2002,[48] and as such, should be introduced into primary care worldwide, as proposed by the World Heart Federation.[49] Nevertheless, just increasing the level of activity is not in itself sufficient, as has been highlighted in various longitudinal studies.[17,19,20,36] Future cardiovascular risk is conditioned more by the physical fitness attained (especially strength and aerobic capacity) than by the level of physical activity undertaken. Finally, it should not be forgotten that, although the level of physical fitness has recently been proposed as a powerful indicator of the state of health at all ages, classic factors of future cardiovascular risk, such as the anthropometrical characteristics,[50] the lipid profile,[51] or blood pressure,[52] all determine the onset of cardiovascular disease. Future studies, therefore, should be based on these factors to learn more about the current state of health of Spanish adolescents.

CONCLUSIONS

Reference values have been established for the physical fitness of Spanish adolescents. These values will enable the level of physical fitness of any Spanish adolescent to be evaluated and correctly interpreted. The results show that the 5th percentile obtained on the 20 metres Shuttle Run test (maximum aerobic capacity) in this study for adolescent boys and girls (ranges, 2.0-3.3 and 1.4-1.9, respectively) was also a biological indicator below which the level of physical fitness can be considered pathological. The state of fitness of Spanish adolescents is worse than that of adolescents in other countries, and 1 in 5 Spanish adolescents are estimated to have a level of physical fitness indicative of future cardiovascular risk. Evaluation of this aspect and the importance of physical fitness as a cardiovascular risk factor highlight the need to design prevention programs to improve the physical fitness (especially strength and aerobic capacity) of Spanish adolescents. To this end, the direct involvement of those working in health care, education, the government, and politics is crucial.

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